

# Entomology



## Chapter Goals:

After completing this chapter, volunteers should be able to:

- Explain the organizational structure of common Classes within the Phylum: Arthropoda, including the Order of Insects.
- Be familiar with field guides available for reference and current accepted practices for collection.
- Differentiate types and characteristics of insect wings for identification.
- Name the most common places to look for bed bugs in a hotel.
- Identify three insects that are beneficial and three that are pests.
- Use the Orders Attachment as a quick identification guide to characteristics of Insects.

## Introduction

From the high alpine tundra to the southern deserts and everywhere in between, Idaho is richly populated with insects. Idaho offers opportunities to view some of nature's most amazing insect spectacles: Mormon cricket swarms in the desert steppe lands, Pine Whites in the ponderosa pines along the Payette, dragonfly migrations on the Cotterel Mountains in the fall, and, of course, mountain meadows filled with butterflies – after all this is Idaho! The superlatives abound, insects are the most specious, most abundant, most ecologically important, most colorful, most cryptic, most awesome, and most fun!

## Why Study Insects?

Insects make up a nearly 60% of all life on the planet (Figure 1). They were around before the time of dinosaurs and they are still around today. They are the most successful form of life, utilizing all imaginable niches and some you cannot imagine. In this chapter, we will discuss some of the common orders and families of insects with a special emphasis on insects common to Idaho, a brief overview of insect study, and some of the adaptations and behaviors that make insects the most successful life form on the planet. This chapter is a meager beginning to the vast riches of knowledge, wonder, fascination, and joy that can come from insect study, if you choose to wander down the entomological path.

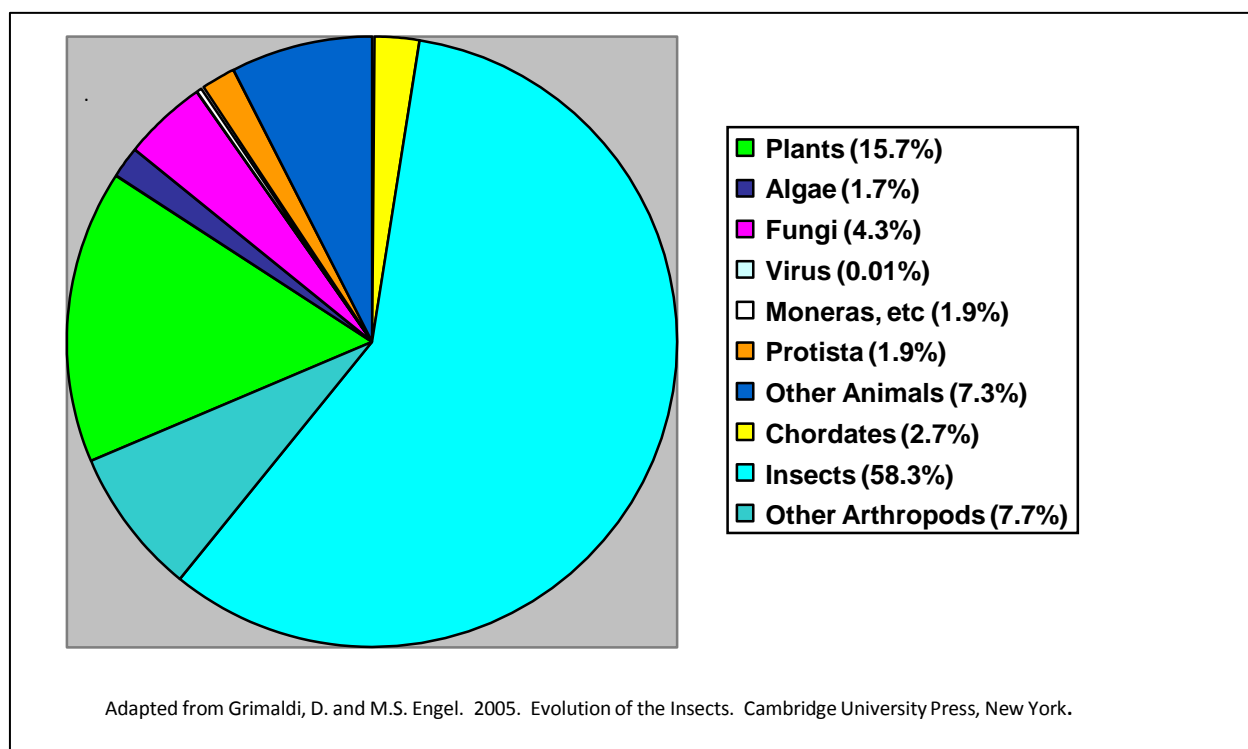


Figure 1: Diversity of Life on Earth

Insects are astonishing because they are so diverse and have adapted to fill thousands of niches that many people may not even know exist. Of the 800,000 or more species known to exist, less than 0.1% are considered pests. Actually, most are considered beneficial. Most people know of the “good” insects, like pollinators and butterflies, but most people do not realize the overall importance of insects. Insects are detritivores, predators, plant feeders, and bloodsuckers. They build soils, influence plant distributions, and generally make most non-marine ecosystems function. They are important in determining ecosystem health because many act as bio-indicators. Because insects have highly specialized habitats, if a particular insect is thriving, it is assumed that the specialized habitat is healthy.

Many insects are part of what we like to call “Mother Nature’s Clean-up Crew.” Imagine if we did not have insects. What would the planet be like? They eat just about anything you can image, including many that eat things we wouldn’t like to have piled around us, like decaying plant vegetation, dead animals and poop. Nevertheless, they consume these “delicacies” and recycle them back into the soil.

They have astounding behaviors: mimicry, bizarre mating rituals and defense mechanisms. Some insects are parasitic; others can learn and communicate. Some insects have social hierarchies. Insects can exhibit parental care. Some are brightly colored or metallic and have been used for jewelry since the time of the ancient Egyptians. Some insects have been used

medicinally to clean or suture wounds. In some countries, some insects are even considered delicacies. Insects are also effective biological control agents for a wide variety of undesirable organisms.

Insects are capable of long-range dispersal as demonstrated by our State Insect, the Monarch Butterfly. Passive, long-range dispersal can also occur via storm systems, driftwood, or other such means. Human activities also provide a medium for passive long-range dispersal of insects. Some of these dispersal events (or introductions) are intentional such as biological control agents; *Hylobius transversovittatus* is a European weevil introduced to control purple loosestrife. Other introductions are accidental. An example, furniture is produced from trees grown in Asia. Wood-boring insects feed as larvae inside the trees used to make furniture sold in America. Sometimes, once the furniture is brought into your home, a critter comes out that hitchhiked unnoticed. Similar pests have been introduced on foods we import. The U.S. government has an agency that monitors goods coming into the country. However, many insects are missed. Insect populations that develop as a result from these events may or may not persist in the environment. Several introduced insects have done very well in Idaho. The Cabbage White, Asian Multicolored Ladybug, and European Earwig are just three of many introduced insects that have become commonly encountered members of Idaho's insect fauna. The designations: native and introduced are utilized to indicate whether humans or human behaviors were the agent of the introduction. This becomes blurred when human caused habitat alteration enables the colonization of new territories, i.e. range expansion. As you spend time in the field, you will find, and maybe even document, some long-range dispersers and possibly even first occurrences within the State.

Another interesting aspect of insect study is insect societies. Many insects will be found in large aggregations at some point. The famed over-wintering sites of the Monarch are an example of this phenomenon (Figure 2). Aggregations are worthy subjects of study, but insect societies are a step beyond mere aggregations. Termites, ants, bees, and wasps exhibit social behaviors in which: young are cooperatively reared, generations overlap, and polymorphism of members exists, i.e., members of the colony look different from one another.

Polymorphism facilitates the division of task specialization within a caste society, i.e., reproductive and non-reproductive individuals, workers, or soldiers, etc. Insects that have a caste system are often called “*eusocial*” and the individual colonies of these societies may be thought of as a single ‘super-organism’ comprised of all members of the colony. These colonies can last for decades. These insects demonstrate language, communication, and learning and are fascinating subjects for study.

Lastly, we wish to discuss an area of study that is rapidly expanding - insect conservation. We have attempted to describe the significance of these creatures so that you understand our world relies on theirs. Given the importance of the ecological services provided by insects, it is imperative that insect diversity is considered in conservation planning. As an example, given the sometimes intricate interdependence of pollinator and plant; conservation of a rare plant may require conservation of a rare pollinator. Data from Great Britain and Canada suggests that insects show the effects of habitat change before bird or plant species do, making insects the better “canary in the coal mine” or a bio-indicator for monitoring environmental change.



Figure 2: Aggregations of Monarchs,  
Pacific Grove, CA

## How Does One Study Insects?

Entomology can take many different forms and professions in entomology are almost as diverse as insects. An entomologist can have a career in ecology, taxonomy, museums/zoos, agriculture, forestry, urban pest control, and veterinary, physiological, behavioral, genetic, medical and forensic sciences to name a few. Engineers study mechanics of insect behaviors and movement to aid in the development in new technologies. Therefore, there are many different approaches to study insects and a beginner can easily become overwhelmed. Do not despair. There is help. The Idaho Entomology Group

(<http://my.collegeofidaho.edu/campus/community/museum/IEG/index.html>) is a fantastic place to find help filled with many wonderful, entomophilic people (i.e. bug-loving people).

Membership dues are \$5 / year (US \$10 / yr overseas), used to cover costs of the newsletter.

Application can be made to the Idaho Entomology Group, c/o Museum of Natural History, The College of Idaho, Caldwell, ID 83605, USA. To achieve maximum, benefit you should try to participate and attend group-sponsored events.

The North American Butterfly Association has a Fourth of July Butterfly Count program (<http://www.naba.org/>). This program is similar to the Christmas Bird Count. Idaho has quite a few of these counts and beginners are always welcome. Other entomological happenings occur in Idaho, your local Audubon chapter and Idaho Department of Fish Game non-game biologist may be able to help.

Traditionally, the study of insects has involved making collections. Insect collections are excellent to help you understand insect taxonomy, distributions, and timing of life stage. Borror and DeLong's *Introduction to the Study of Insects* (various editions) has instructions for creating and preserving an insect collection that will get you started. Many schools, government agencies,

and museums have insect collections that you may be able to visit. The Lepidopterist's Society ([www.lepsoc.org](http://www.lepsoc.org)) statement on insect collecting is a good guideline to collecting ethically. In 1974, noted lepidopterist (butterfly guru), Robert Michael Pyle, and Seattle Audubon put out a book called *Watching Washington Butterflies* which ushered in a new, more insect friendly, “catch and release” paradigm for recreational enjoyment of insects. Unfortunately, some people have become strident anti-collectors and this has polarized the entomological community in some states. Luckily, Idaho has avoided these problems so far. Each side has much to gain and learn from the other and together represent a balanced and efficient approach to insect study – to be respectful of other people, natural communities, and the insects.

The development of close focusing binoculars has greatly enhanced insect study. Many binoculars now exist that can focus within five feet. This allows up close views of insects without disturbance and can yield important behavioral observations. Many of the birding binoculars are also excellent for insect watching, and you may already own this observational tool.

Another recent development is high-quality digital cameras (both still and video). They have facilitated field photography of insects. Digital cameras that have a screen instead of a viewfinder allow you to move the camera, as opposed to your head, allowing a much closer approach to the insect (Figure 3). The gear required is neither expensive nor cumbersome. For example, the Nikon S7c is a fantastic camera that will give good results under most conditions, costs under \$200, and fits in a shirt pocket (many of photographs in this document were taken with the Nikon S7c). Good photography is not a result of having the best gear.

Knowing how to use your camera and being willing to become intimately involved with your subject is what leads to good photography. Insect photography is so prevalent that photographs are now accepted as vouchers to document occurrence for many taxa. Another advantage of photography is it makes a great addition to your field notes, allowing you to continue your learning from time in the field, long after the outing. Your photography can be even more powerful by utilizing it to document occurrences and distribution of various insects. Two of the best county distribution sources, *Butterflies and Moths of North America* and *Odonata Central*, are on the web at [www.butterfliesandmoths.org](http://www.butterfliesandmoths.org) and [www.odonatacentral.com](http://www.odonatacentral.com). Both sites have ready access to distribution data and easy to follow submission protocols.



Figure 3: Taking photos can assist in the identification process when specimens are not collected

In addition to simple occurrence, insects offer wonderful opportunities to observe and study behavior. Niko Tinbergen's 1984 book, *Curious Naturalists* demonstrates the value of an observational approach to insect study. Photography and video are both great tools for documenting behaviors.

Another popular insect study avenue is rearing insects. Many books exist on this subject, but Borror and DeLong's *Introduction to the Study of Insects* (various editions) will get you started. Usually, this approach will yield insight into insect interactions with plants. However, as those of you who have seen the Conservation Seeding and Restoration, Inc. dermestid beetle colony at various fairs and events know, you may find out how insects interact with a dead antelope or other food sources.

Borror and DeLong's *Introduction to the Study of Insects* has instructions for building a net, and you will find that you can make much of your equipment. Some things you will find it easier to buy. There are many biological suppliers, such as [www.bioquip.com](http://www.bioquip.com) that sell specialized entomological equipment. Equipped with a net, close-focusing binoculars, camera, field notebook, and appropriate field guides you are now ready to embark on a journey into the world of insects!

Identification of many insects can be tricky as the identification resources exist in scattered technical journals if they exist at all, not to mention all the scientific jargon that requires an entomological dictionary to decipher the language in technical journals. Nobody goes into the field expecting to identify every species encountered. A good, general guide is Kaufman and Brock, *Insects of North America*. It will usually take you at least to "family." There are many web based identification tools. Currently, [www.bugguide.net](http://www.bugguide.net) is the best general on-line guide. As you specialize, you will find others. There are numerous, excellent field guides that exist for many of the most watchable species. Tim Maniolis, *Dragonflies of California*, covers Idaho amazingly well. Robert Michael Pyle, *Butterflies of Cascadia*, is wonderful. *A Field Guide to the Tiger Beetles of North America* by Pearson, et al. is great introduction to an awesome group of insects. There are many others. The identification of these animals will require knowledge of the different types of antennae, legs, mouthparts, etc. Below, this information is presented in general terms.

## Characteristics of Arthropoda

Before we get started on the insects, it is beneficial to begin at a higher level of organization because many animals are called insects but they are only relatives. Therefore, we will start by examining Arthropods (Figure 4) and work our way to insects.

Arthropods have segmented bodies, usually grouped in two or three distinct regions. They have paired segmented appendages. They have bilateral symmetry, which means, if you divided the animal in half longitudinally, the left side is a mirror image of the right side. They have exoskeletons made of chitin and the exoskeleton is shed periodical during growth processes. They have a tubular alimentary canal that connects a mouth to the anus. They have an open circulatory system, striated muscles, a simple nervous system, and a respiratory system that is composed of gills, trachea or spiracles. There are usually both males and females instead of one animal having the capability of being both male and female.

## Classes of Arthropods

Classes in the phylum Arthropoda are contained within three subphyla.

- Chelicerata - spiders, scorpions, whipscorpions, pseudoscorpions, and mites
- Crustacea - crayfish, crabs, copepods, isopods, barnacles, and water fleas
- Atelocerata - millipedes, centipedes, symphylans, and insects.

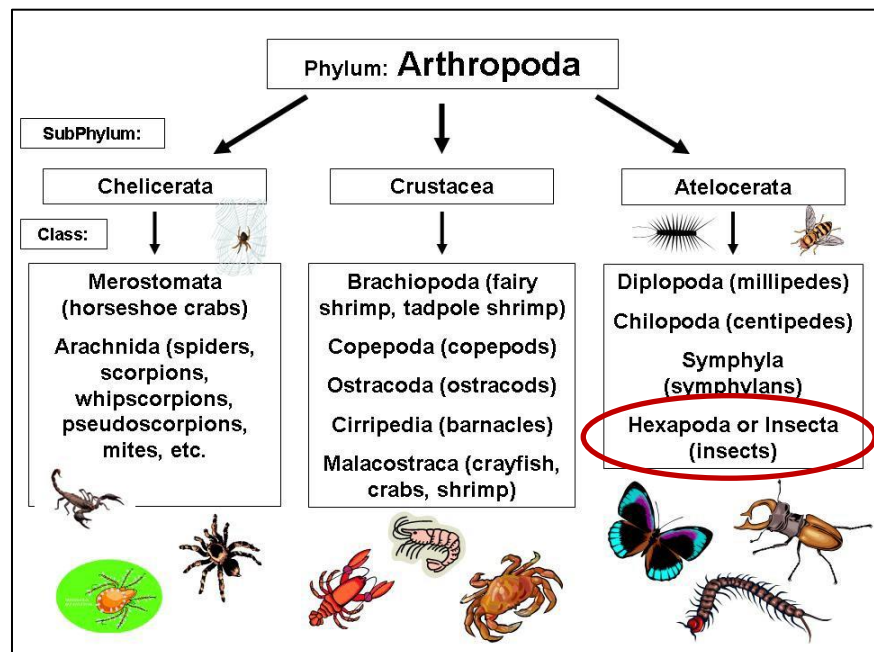


Figure 4: Flow chart depicting the organizational structure of common Classes within the Phylum: Arthropoda.

Of these varied and fascinating organisms, only insects are truly insects.

The animals more commonly confused by lay people as insects are: Arachnidia, Diplopoda, and Chilopoda. Arachnidia (spiders, mites, etc.) are in a different subphylum and have two body parts, the cephalothorax and abdomen. They have four pairs of legs and no antenna or wings. Diplopoda are the millipedes and they feed on decaying plants and fungi. However, if populations get large enough, they can sometime injure healthy plants. They have two pairs of legs per segment, which causes them to be much slower than their cousins, the centipedes.

Their body is round in cross section and they have relatively short antennae. Chilopoda are the centipedes. These animals have only one pair of legs per segment and are capable of moving

much faster than millipedes. This is good because they prey on other arthropods which means they need to be quick. Centipedes produce toxins to kill their prey, and will bite humans if they are disturbed or feel threatened. Unlike millipedes, they are flat in cross section and have longer antennae. Now that we know what an insect is not, let us begin with insects.

## Insecta

Class Insecta has three distinct body segments (head, thorax, and abdomen), two pairs of wings (if present) and three pairs of legs. In this section, we will discuss each portion of the body of the insect to understand the morphology of these animals.

### Head

On the head, there will be one pair of antenna, mouthparts and compound eyes (Figure 5).

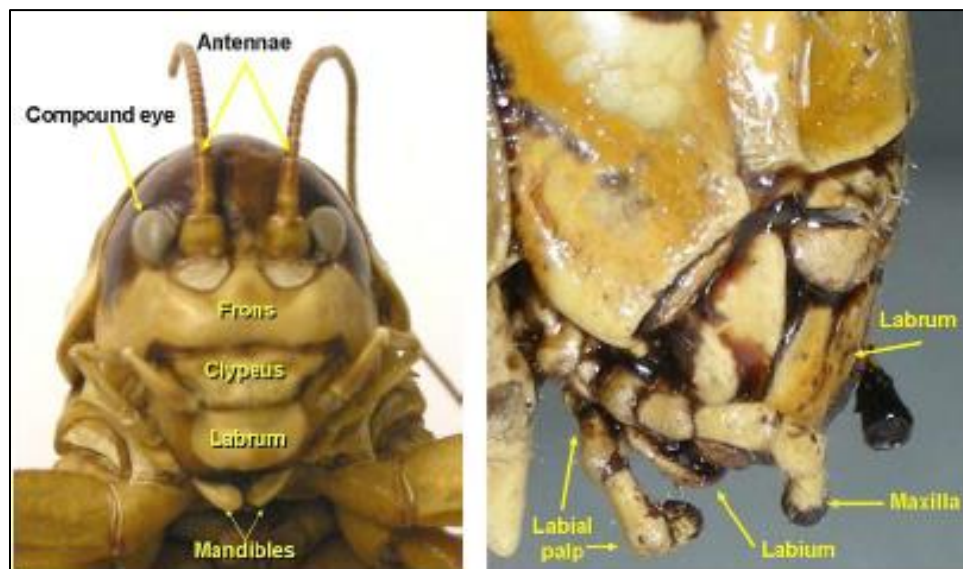


Figure 5: Structures located on the head of an insect.  
The photograph on the left is front view of the face of a camel cricket and the right is a side view of an Acridid grasshopper

### Mouth

As we study the mouth of an insect, you will see, in many ways, it is just like ours. They have two lips and a tongue. However, their jaws and teeth are a single unit. Mouthparts are often arranged in such a way that structures do not look the same when comparing the different types of mouths. Hence, you will see there are extreme variations of the mouth. There are two main categories of types of mouths: *mandibulate* (chewing) and *haustellate* (sucking).

- *Mandibulate (chewing) Mouthparts* - The classic depiction is shown in Figure 5. Chewing mouthparts are found in most insects, such as beetles and dragonflies. The labrum is the “upper lip” and the labium is the “lower lip” of an insect. The labium has a feeler-



Figure 6: Sickle-like mandibles used to tear apart food.

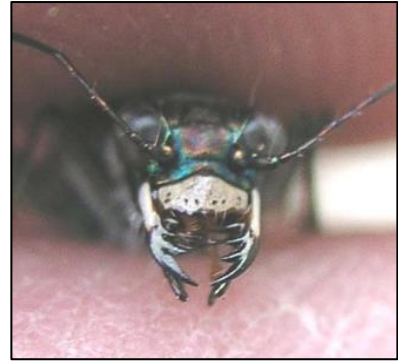


Figure 7: Mandibular teeth on a tiger beetle.

like structure on both sides of the labium called a *labial palp*. *Mandibles* are the jaws and teeth wrapped up in one (Figure 6). They are located between the lips. Most mandibles have grooved surfaces or ‘tooth-like’ projections. They are aptly named, *mandibular teeth* (Figure 7). Mandibles move side to side instead of up and down as they masticate food. The shape of the mandible can be quite varied. The maxillae are another pair of feeler-like structures located behind the mandibles. Both maxillae and labial palps assist in the maneuvering of the food. The *hypopharynx* is a tongue-like structure located behind the mandibles and is not visible without the mandibles.

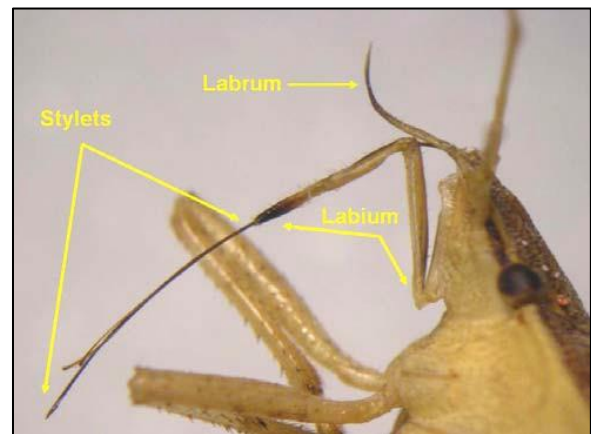


Figure 8: Slender mouth of pythophagaous stinkbug (top); broad mouth of a predaceous assassin bug (bottom).

- *Haustellate (sucking) Mouthparts* - The mandibles in haustellate insects are modified such that they are not used for chewing but are adapted for sucking. In some cases, the mandibles may even be lacking. This form of mouth is often referred to as Proboscis, or a beak, and is found on flies, true bugs, butterflies, and others. Within the haustellate groups, there are variations of sucking mouthparts.

The Hemiptera, or true bugs, have a beak (Figure 8) that is modified for piercing and sucking. The outer sheath of the beak is the labium, which is segmented, and houses the stylets. There are four stylets, which are modified mandibles and maxillae. The mandibles and maxillae form the salivary and food channels. Hemiptera will often inject their saliva into to their food to assist in the digestion of their food. Within the predaceous Hemiptera, such as Assassin Bugs, the saliva can paralyze its victim for easier eating. When a Hemipteran pierces its food, the stylets are the only portion that penetrates the food while the labium folds up. The labium is not involved in the piercing of the food. Since the Hemiptera all have piercing-sucking mouthparts, it may be beneficial to know that most predaceous Hemiptera have shorter, broader mouths than the pythophagaous (plant feeding) Hemiptera. This can be useful when handling Hemiptera, because like most animals, when threatened they may bite!

There are other variations of sucking mouth parts. We will not go into all the specifics as to what makes the sucking mouth parts of flies and butterflies different from those of a true bug, but by looking at Figures 9, 10 , and 11, one can see how the mouths look different. Even though the mouths look VERY different, most if not all of the same mouth parts are present, but they are arranged differently. Biting flies also have haustellate mouthparts for piercing and sucking. The mouth of a mosquito is almost needle like,



Figure 9: Mouthparts of Tabanid Flies



Figure 10: The flexible, drinking straw-like mouthparts of the Western Tiger Swallowtail.



Figure 11: Sponging/lapping fly

whereas, horse flies have a more knife-like mouth. It is partly because of the differences in mouthpart size that you can feel the bite of a horse fly more so than a bite of a mosquito.

Many of the Lepidoptera have mouthparts that can be described as a flexible soda straw (Figure 10). When not in use, the straw is carried neatly rolled up between the labial palps. This arrangement allows the “straw” to delve into flowers at the appropriate distance to exploit the nectar in deep flowers, while also providing aerodynamic efficiency and protection to valuable mouthparts. Sponging/Lapping flies - The proboscis (i.e., beak-like mouth) of non-biting flies consists of two main parts, the rostrum and haustellum (Figure 11). This arrangement is very efficient for handling the liquid and semi-liquid diets of the adult Diptera and is subject to great variation within the families of the order.

## Antennae

Antennae are located on the head, usually between or below the eyes. There are three (Figure 12) parts to an antenna: scape, pedicel and flagellum. The scape is where the antenna attaches to the head. The pedicel is between the scape and the flagellum. Everything beyond the pedicel is the flagellum. There can be as many as 70 antennal segments and 68 of them would be considered the flagellum. The primary purpose of antennae is olfactory receptors. Essentially, they are the insect’s nose. They also can be involved with regulating speed and stability of speed during flight. Some insects use antennae for holding prey while eating, while others use them in their courtship and mating rituals.

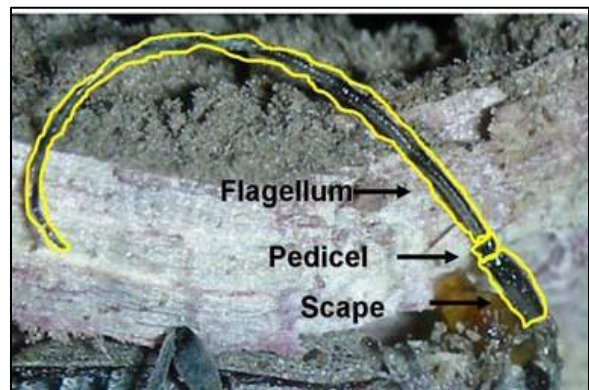


Figure 12: Antenna Morphology

Antennae are quite variable between insect groups and they are important in the identification process. Attachment 1 provides the terms and brief descriptions of antennae as well as some insects that have a particular antennal type.

## Compound Eyes

The compound eye is made up of several (or several thousand) individual units called ommatidia. This is different from our eyes, which, while complex, function as a single unit. This means insects perceive the world differently than we do (Figure 13). At 20 frames per second, we see a movie – movies made for insects would need 180 frames per second. (This may be why most cartoon studios do not make cartoons for insects). This allows insects to perceive

form even when in rapid flight. Some insects even have stereoscopic vision allowing them to accurately judge distances. Insects can see ultraviolet light. Some insects can even analyze polarized light. The mosaic theory of insect vision (as depicted in figure 13) is old, but insect vision is not yet fully understood.



Figure 13: Simplistic depiction of what humans see (left) compared to what an insect sees (right).

## Thorax

There are three segments making up the thorax. Each segment possesses a pair of legs. Wings, if present will also be on the thorax.

- *Locomotive appendages* - Legs are located on the thoracic segments, one pair of legs per thoracic segment. Legs typically have six segments: the coxa, trochanter, femur, tibia, tarsus, and pretarsus (Figure 14). The coxa is where the leg attaches to the thorax. The trochanter is usually one segment and is in between the coxa and femur. The femur is the first long segment of the leg, followed by the tibia. The tarsus is a part of the leg that appears to have multiple segments, but is actually more like sub-segments. Lastly, the pretarsus is the 'foot' so to speak, the claws and pads at the end of the leg. On immature forms of certain insects, there are leg-like structures, prolegs, on the abdomen. These are used for locomotion also, but they are not true legs and are not segmented. Prolegs are, however, useful in identification.

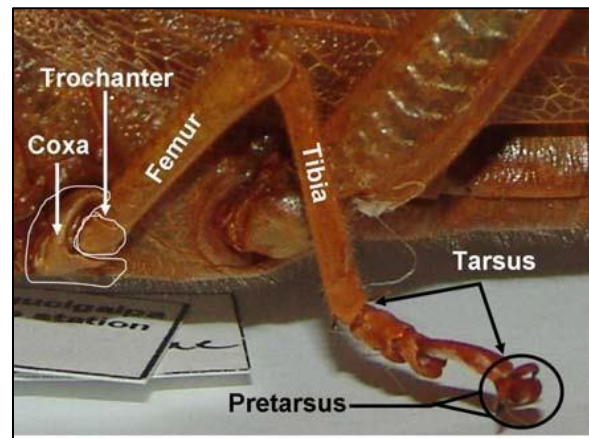


Figure 14: Morphology of an insect leg.

The primary and most obvious purpose of legs is for locomotion. However, insects such as dragonflies have legs that are not designed for locomotion. They are adapted to form a basket to assist in the capture of prey. Bees, butterflies, and flies have structures on their legs that are used to taste plants before ingesting them. Some insects also have modifications that are used during the grooming process. Additionally, the shape of the legs can also reveal information about the insect's behavior and/or habitat. For example, raptorial legs are adapted for grasping and holding prey; having raptorial legs suggest a predatory life style.

Another character that is often associated with predaceous animals is quickness for capturing prey. Many predaceous insects have cursorial (long, skinny legs) for running. However, not all long, skinny-legged, fast running insects are predaceous. For example, roaches are not predaceous but have cursorial legs. An insect with *nautorial* legs (many long hairs on the legs) is often a sign that it is an aquatic insect. The hairs on the legs assist with swimming. Another leg modification is for insects that live underground and have to dig to get underground. The leg type is called *fossorial*. The legs are broad and usually have tooth-like projections that assist in the shoveling of the dirt to maneuver themselves underground. A sampling of different leg types is shown in Figure 15.

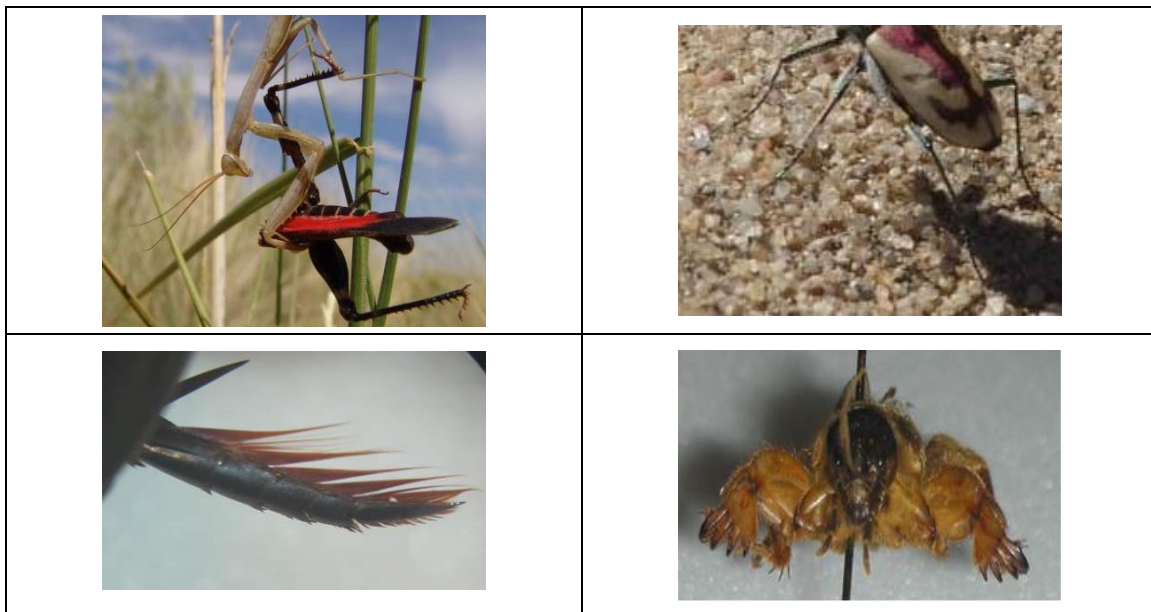


Figure 15: Types of legs: *raptorial* legs on a preying mantid (upper left), *cursorial* legs of a tiger beetle (upper right), *nautorial* legs of a water beetle (lower right), and *fossorial* legs of a mole cricket (lower left).

- *Wings (if present)* - Although the primary purpose for wings is flight, there are several variations of the wings. Most insects have two pairs of wings, the forewing (the first pair of wings) and the hind wings (the second pair of wings). Wings are attached to the second and third thoracic segments. Some insects are wingless and true flies have modified hind wings called halteres. Often the wing type is a good clue as to where to begin in identifying an unknown insect. Insect wing types, descriptions, and insects that exhibit the wing types are shown in Attachment 2.

In many insect groups, the pattern of venation is an important clue as to species identity. The veins are hollow structures that may contain nerves, trachea, and hemolymph (insect blood) and serve to provide strength to the wing. As might be expected with something so important, several systems exist to name these veins. Do not be surprised to find that

different references utilize different terminologies for the same structure. Do not get frustrated. Utilize it as an opportunity to become more diverse!

## Abdomen

The abdomen of an adult insect does not have appendages for locomotion. However, immature forms may have leg-like structures on the abdomen. There may also be a variety of abdominal appendages though, like cerci. The abdomen also harbors the reproductive structures.

- *Genitalia* - The external genitalia of male insects are diverse beyond imagination and can actually resemble a Swiss Army

knife in both form and function. In many insects, determining which species you are examining may require examining the genitalia. Secondary sexual structures can also be important. Happy is the photographer whose dragonfly photo has a clear shot of the cerci of the male because determining the species photographed has just gotten much easier.

- *Abdominal Appendages - Prolegs* are abdominal appendages that several caterpillar-like larvae possess (Figure 16). Prolegs are not true legs, but they are used for locomotion. Beetles do not have prolegs but Lepidoptera; some that have prolegs (sawflies) look similar to Lepidopterous caterpillars. However, they have more than 5 prolegs. Additionally, Lepidopterous larvae have crochets (hook-like structures on the “feet” of prolegs), and sawflies do not have crochets.

*Cerci* (Figure 17) come in all shapes and sizes. There are numerous uses for them. Earwigs have forcep-like cerci sometimes used as a defense mechanism and can be used to assist in the capturing of prey. Some insects, like the dragonflies mentioned above, use cerci when mating.



Figure 16: Crochets on a proleg.



Figure 17: Cerci of earwig.

## Metamorphosis Types

Insects undergo a process (metamorphosis) where they transform from the immature form (most often referred to as the nymph, larva, or caterpillar) to the adult stage. One common myth about insects is that if the insect is small, even if it has wings, it is a “baby” insect. If an insect has its wings, it is an adult and it will not get larger in time – the exoskeleton limits how big an insect can get. There are several processes that baby insects utilize to become adults. As an immature insect increases in size, it will shed its old exoskeleton and produce another, larger exoskeleton until it reaches adulthood. The old exoskeleton they shed is called an *exuvium* (exuvia is the plural form) as shown in Figure 18.



Figure 18: Exuvium of a grasshopper.

### Simple/Incomplete/Gradual Metamorphosis

There are multiple types of simple metamorphosis. It is also called incomplete or gradual metamorphosis. Insects that go through an egg stage, immature stages, and adult stage experience simple metamorphosis. One common aspect of this type of metamorphosis is that wing development is external, if wings develop. Additionally, there is no period of inactivity as in complete metamorphosis.

- *Ametabolous Metamorphosis* - During ametabolous metamorphosis, the immature forms look identical to the adult form but smaller. Eggs are laid and the immatures pass through several molts (nymphal stages) until they reach sexual maturity and are then called adult. The number of molts will vary depending on the species. An example of an insect that undergoes this form of metamorphosis is silverfish.
- *Hemimetabolous Metamorphosis* - Another form of simple metamorphosis is hemimetabolous metamorphosis. In this type of metamorphosis, the immature forms look different than the adults. They, like insects that undergo ametabolous metamorphosis have several molts as immatures. The number of molts is species specific. Dragonflies and mayflies complete their life this way.

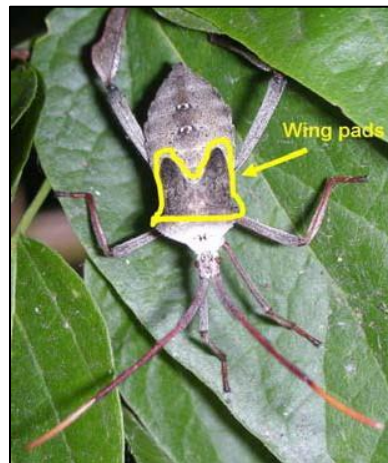


Figure 19: Photograph of wing pads of a leaf-footed beetle.

- *Paurometabolous Metamorphosis* - Insects that undergo this type of simple metamorphosis look similar to the adult as immatures. Their wing pads (Figure 19) become more noticeable as they get closer to adulthood. The true bugs of the Hemiptera are an example of an insect group that undergoes this type of metamorphosis.

## Complete Metamorphosis

**Holometabolous Metamorphosis** - Complete metamorphosis differs from simple metamorphosis in that wing formation is internal and there is a period of inactivity called the pupa. Insects that undergo complete metamorphosis have an egg, immature stage (usually called larva), pupa and adult.

- *Larval Types* - Finding larval insects in the field is always exciting. Because they often look very different from the adult forms, being familiar with the different larval types will prove useful. Photographs of each larval type are provided in Figure 20.
  - *Vermiform* larvae are maggot-like or worm like. They are legless and may or may not have a well-defined head.
  - *Elateriform* larvae are cylindrical shaped with short legs. This form is representative of the wireworms.
  - *Eruciform* larvae are caterpillar-like larvae. They have well developed heads with short antennae. They have both true legs and prolegs.
  - *Campodeiform* larvae have an elongated, somewhat flattened body. They usually have well developed antenna.
  - *Scarabaeiform* larvae are grub-like and are usually C-shaped. They have well developed heads and only true legs.
- *Pupal Types* - From science class, you have more than likely heard “chrysalis” or “cocoon” to describe the stage where a larva transforms into an adult. That terminology is



Figure 20: Larval types: vermiform (deer fly) [top left], elateriform (wireworm) [top right], eruciform (Noctuid moth) (center), campodeiform (lacewing) [bottom left], and scarabaeiform (white grub) [bottom right].

correct but there are more names to describe the stage. Pupa is a general term that is always correct for this stage, whereas, cocoon refers to a type of pupa. Knowing the pupal type (Figure 21) will give you some idea as to what to expect when the adult hatches from the pupa.

- Insects with *obtect* pupal forms have the appearance that their appendages are “glued” to the body within the pupal case. The pupa may be protected within a cocoon. Lepidoptera and some Diptera have this pupal type.



- The appendages are “free” in *exerate* pupal forms. These pupae resemble a mummified adult. They are not covered by a cocoon. This is probably the most common pupal type of insects that undergo complete metamorphosis. However, Lepidoptera and Diptera will not have this form.



Figure 21: Obtect (top-left), Exerate (top-right), and Coarctate (bottom) pupae.

- The *coarctate* form is similar to the exerate pupa, but the appearance is different in that the pupa is covered with a hardened cuticle. Therefore, it does not have the appearance of a mummified adult. Diptera often have this pupal type.

## Insect Senses

We touched on some of the senses that insects have, but it is important to realize that the world we share with insects is perceived differently by the different insects and by us. Most of the sensory components are located on the antennae and legs, but insects can have sensory organs in places that we cannot imagine. In some cases, there are structures that appear to be sensory in nature, but for which the function has eluded entomologists. An interesting case in point is the Noctuid moths. Many male Noctuids find females ready to mate by following a pheromone trail well below our threshold of detection. Often, these same moths can hear the ultrasonic “radar” of bats (fearsome nocturnal moth predators) with their abdomen and take appropriate actions. Probably they see wavelengths of light we can’t, and taste chemical differences in plants of the same species. Some bees can sense the Earth’s electromagnetic field. Many insects have the ability to see polarized light and others have the ability to track time. It is not that we are not

exquisitely adapted to our world; it is just that sometimes understanding insect behavior will require thinking outside of our own sensory box.

## Habitat Utilization

One of the reasons insects are so successful is many orders of insects avoid competition between offspring and adults by having a holometabolous life style (i.e. complete metamorphosis). A good example of this lifestyle is one of Idaho's most stunning butterflies, the Gillette's Checkerspot (*Euphydryas gillettii*). Eggs are typically laid on carefully selected leaves of twinberry honeysuckle in montane meadows. The caterpillars (or larvae) hatch out from the eggs and feed for 1-2 years on the leaves of the host plant accumulating the biological capital (i.e., stored fats from feeding) that the adults will later spend. In the pupal stage, the magic of transformation occurs and results in an adult butterfly. The adult Gillette's Checkerspots feed primarily on flower nectar – their tubular mouth parts are entirely different from the chewing mouthparts of the caterpillar. The adult is designed for reproduction and dispersal. The caterpillar is a perfect eating machine and consumes the vast majority of the food intake during the butterfly's life span. Furthermore, some adult insects, like mayflies, do not have functional mouthparts – their sole purpose is to produce offspring and disperse.



Figure 22: Adult and immature aphids being tended by ants.

Not all insects follow this life cycle pattern. Many orders have simple or incomplete metamorphosis processes. In some of these orders you will find adults and nymphs utilizing the same food resource. Next time you see aphids, take a closer look and you will see adults and the very similar nymphs (larvae) feeding side by side (Figure 22). An incomplete metamorphosis doesn't necessarily mean adults and larvae will utilize the same resource. Adult dragonflies and dragonfly nymphs are both obligate predators; but the adults are masters of the air, and the nymphs are aquatic predators. Competition between life stages is minimized by utilizing different food resources.



Figure 23: Asilid fly with dragonfly prey - an example of predation on predators.

Insect habitat utilization can be demonstrated by thinking of spinach as a food resource; for us it is a little vinaigrette, a fork and bon appétit. Insects don't always approach leaves the same

way. Because of size related issues (a.k.a. scale), many more niches or ways of exploiting this resource exist. In addition to defoliating, insects may be skeletonizers, miners, gallers, borers into leaf petioles or main stems, or feeders on vascular tissues. When the entire plant is considered, the number of niches increases. Some insects prefer young leaves compared to old leaves. The cuticle of older leaves may be too tough for some insects, while others may utilize an older leaf because certain plant compounds may be diluted in the old leaves (due to the relative surface area between younger, small leaves compared to older, big leaves or vice versa). Insects even feed underground on the plant roots.

Of course, this many insect herbivores create opportunities for insect predators (Figure 23). There are a plethora of insect predation strategies. In addition to the various outright predation strategies, insects have developed a bewildering array of parasitism lifestyles (Figure 24). If you examine caterpillars in the wild, you will find some with external parasites. If you rear larvae collected from the wild, you will also have some larvae that become something other than the species expected – you will have reared internal parasites. As TV commercials say: “but wait there’s more...” In the orders: Diptera, Coleoptera, and Hymenoptera, there are species that have taken on a lifestyle of hyperparasitism. A hyperparasite is parasitic on an external or internal parasite of a host insect. In other words, the parasite has parasites. This highly evolved lifestyle can be obligate (the insect can only parasitize parasites) or facultative (can be a primary or secondary parasite). In addition, it is important to note that there are generalized parasites that can utilize many insect species as a host, and specialized parasites that are more restricted to feed on a few species.



Figure 24: A moth caterpillar, *Helicoverpa zea*, with an unknown Hymenopteran internal parasite leaving the host to pupate.

As a vertebrate, you think of habitats as immense things and ultimately, everything is connected. We hope that the above discussion has created an awareness that insect habitats can be on an entirely different scale than most people are used to thinking about them. (The movie *Microcosmos* (1996) is an enjoyable, visual tour of the scale issues we are trying to communicate. Viewing this movie is highly recommended.). We have discussed two resources that insects eat (plants and insects), but insects utilize many other resources (e.g. fungus, humans, carrion [Figure 25]) and do so with similar degrees of complexity.

## Orders of Insects

We are now ready to begin discussing the different orders of insects. It is probably appropriate to refresh our memories of exactly what is an order. An order sits in between class and family in the taxonomic hierarchy (a.k.a., Kingdom, Phylum, Class, Order, Family Genus, and Species). As an example, the woodpeckers are in the order Picoformes, of which there are quite a few in North America. Compared to the flies (order Diptera), of which there are almost 20,000 species, the order Picoformes does not appear so diverse.



Figure 25: Carrion

As has been mentioned, insects are hyperdiverse to the point that your head is probably spinning. There are many insect orders and species in North America (Attachment 3). It may be helpful to know the general taxonomic lingo before going further. When you come across “*ptera*,” it signifies that we are talking about the Order of insect, e.g., *Coleoptera*, *Hymenoptera*, etc. The names that end in “*-idae*” are the insects in Family level (*Carabidae*, *Formicidae*, etc.), and groups that end in “*-idea*” is often shortened by calling it, “*-id*” (*Carabid*, *Formicid*, etc.).

In the following pages, we will examine a few of the orders and families that you may have the opportunity to enjoy in the field or of which you should at least be aware. Remember, we are only scratching the surface of the deep body of insect knowledge. It is our hope that this scratching of the body will lead to an itching for more knowledge, and ultimately, the calamine lotion of discovery!

### Collembola

Have you ever been working in the garden, overturned a stone or leaf litter, and seen what appear to be small grey dots jumping? Those are Collembolans or springtails. Collembolans have a structure called the collophore once thought to allow springtails to adhere to surfaces because it is wet and sticky. It was later determined that the primary purpose of the structure involves water uptake. However, Collembolans were named for the collophore before the true purpose was determined (*coll* meaning glue and *embola* meaning a bolt or wedge).

The common name “springtails” came about due to their behavior of jumping when disturbed. They have a structure, the furcula, on the underside of the abdomen that is held in place by a clasp-like appendage, the retinaculum. Once disturbed, they release the furcular moreover, the furcula acts like a springboard, allowing them to propel themselves. They can “jump” 75 –

100mm (3-4 inches). That is quite impressive considering their size is 3-6mm (0.1-0.2 inches). To put that in terms we may better understand, a 5ft human would be able to propel him/her as high as 165 ft. into the air!

With only 6,000 species, this group of insects account for less than 1% of the known species of the world. There are a little less than 700 species within seven families in North America, north of Mexico. Collembola are primitive insects. Some taxonomists do not call them insects because they are so primitive. They put Collembola in a different class all together. They have limited vision and are wingless. Because it is such a small group and they are cryptic, many people never see these critters. Some species occur on vegetation, but most species live in the soil, leaf litter, under bark, decaying logs and in fungi. They can reach large population sizes of 100,000 springtails/m<sup>3</sup> (2800 springtails/ft<sup>3</sup>). They are important insects because they are part of “Mother Nature’s Clean-up Crew”. They feed on (clean-up/remove) decaying plant material, fungi and bacteria. They also take care of pollen, algae, and arthropod poop. Few species feed on vegetation that may also become pests in gardens, greenhouses, and mushroom cellars. They are also important to environmentalists because they are studied as indicator species of soil health. If you have high populations in the soil, it is likely that you have a healthy soil system. The next time you are working in your flowerbeds, look to see if you see any grey jumping dots.

### Microcoryphia and Thysanura

In this segment, we will discuss two small orders of wingless insects: jumping bristletails (Order: Microcoryphia) and bristletails (Order: Thysanura, Figure 26). These insects undergo simple metamorphosis, meaning that the immature forms look similar to the adults but smaller. They are considered the bridge between the primitive wingless insects and the winged insects. The differences and similarities are mostly technical, morphological characteristics that will not be mentioned here. Both are fascinating and worth exploring further.



Figure 26: Silverfish

Microcoryphia is derived from the Greek words *micro* meaning small and *coryphia* meaning head. This is a small group with only 350 species worldwide. In North America, north of Mexico, there are 24 species within two families. They are similar in appearance to the other order we will talk about, the silverfish, but jumping bristletails are cylindrical and have an arched back. They have three appendages coming off the last segment of the abdomen and they have leg-like structures (styli) off each abdominal

segment. Their bodies are covered with scales that may form a pattern, but they are worn off easily, especially if handled. Their preferred habitat is in leaf litter, under bark and rocks, and in

dead wood and they feed primarily on algae. They are active at night and they are capable of “jumping” 25-30 cm. That is more than 10 inches! When these critters molt, they have to glue themselves to a substrate with a substance that looks like poop. If the glue does not harden to the substrate or the substrate is not firm, the insect is not able to molt and it will die. Bristletails comprise another small order that has 370 species worldwide. There are 20 species in North America, north of Mexico, within three families. Their name comes from *thusanos*, meaning bristle or fringe and *oura*, meaning tail. There are two common groups in this order: the silverfish and firebrats. They are approximately ½ inch to ¾ inch in length. Their bodies are covered in scales. They have three appendages (tails) that are “fringed” with “bristles” coming out of their abdomen. They have compound eyes and chewing mouthparts. They can be quite long-lived, may take three years to reach maturity, and may continue to live five additional years as adults.

The more commonly encountered members of this group, because of their association with humans, are the silverfish and firebrats. Silverfish like cool damp places whereas firebrats like warmer places near furnaces and boilers. Both are fast runners and feed on starchy substances. They can be pests in libraries and in homes because they feed on book bindings, wallpaper glue, starched fabrics like curtains or clothing, and starchy foods that humans also like to consume. They are nocturnal. Therefore, they are not often seen damaging items around the house. More than likely, their damage may not be discovered for several years until you pick a book off the shelf after many years and the pages fall out or you move a box from the attic. When you pick it up, the bottom breaks because all the glue from the tape has been eaten by these critters. Some less common bristletails live in decaying trees, caves, mammal burrows, and even ant and termite mounds.

## Ephemeroptera

Adult mayflies are soft-bodied insects that have two or three thread like tails (Figure 27). The forewings are triangular-shaped. The hind wings are smaller than the forewings and somewhat rounded. Both pairs of wings are membranous and held together over their body. The immature form is called a nymph. They live in water and breathe, using gills, which are found alongside the abdomen. They have three tails in the immature stage. They are often confused with stoneflies. However, stoneflies have two tails, not three and the gills are on the thorax, not the abdomen. They undergo a form of simple metamorphosis. It is unique and no other order of insects follows this metamorphosis type. The immatures look very different from the adults. The nymph will swim to the surface of the water and molts into a winged form, the *subimago*; however, it is not a true adult yet. The



Figure 27: Mayfly adult

subimago will fly a short distance to solid ground or vegetation where it will enter its final molt to an adult. The subimago is similar in appearance to the adult, but hairy.

These insects are named for the adult lifespan, which is very short. (*Ephemera* means "for a day" or short-lived, and *ptera* means wings). These insects are synchronous in their development, which leads to huge mating swarms. After mating, females will oviposit (lay eggs) on the surface of water or objects in water. Females die shortly after oviposition occurs and males die shortly after mating. When they die, they have been seen in piles over three feet in height. In situations where carcasses are so plentiful, they can be hazardous to drivers because roads can become slippery with their internal contents smashed onto road surfaces.



Figure 28: *Libellula saturata*, with prey in mouth, on Agave at Idaho Botanical Garden.

These insects are considered good biological indicators of water quality. Different species have different habitat requirements and some are very specialized. Environmental changes are apparent in the mayfly populations. Huge swarms used to be present in the mid-1950's around Lake Erie. However, water pollution increased and mayfly populations substantially decreased. In time, when water quality is restored, large mayfly populations may occur once again. Mayflies are also a large food source for fish. Many fishing lures have been developed to mimic their appearance. Fly fishermen are usually aware of the presence of mayflies. They are also food for birds, predaceous insects, spiders and amphibians.



Figure 29: A dragonfly nymph in a mountain lake (above) and an empty nymphal skin, or exuvium of a dragonfly (below).

## Odonata

Odonates are incredible! Adult dragonflies (Figure 28) are masters of the air: fast flying, extremely maneuverable and equipped with extraordinary senses. They are large, colorful, sometimes territorial, predatory insects with fascinating behavior. They display most of the hunting characteristics of raptors (hawks and falcons). Their prey can eat anything from smaller flying insects to other odonates. Odonates go through three stages in their life cycle: egg, aquatic larvae (Figure 29) and adult.



Many species of odonates insert their eggs into emergent vegetation. When emergent vegetation around a body of water is removed, these species are also removed. Some odonates will lay eggs in soil near bodies of water, which makes them susceptible to trampling and other such disturbances. Because fluctuating water levels often preclude the establishment of aquatic vegetation, reservoirs are poor habitat. A lack of aquatic vegetation greatly reduces dragonfly production. If the aquatic habitat is free of fish, dragonfly larvae are usually the top aquatic predator. Waters that contain fish will produce significantly less dragonfly adults (according to some studies, 80-90 percent less) due to predation by fish.

This can put Odonate conservation at odds with fish stocking for recreational purposes in otherwise fishless waters (i.e. mountain lakes) because some species of Odonata simply cannot survive in the presence of predaceous fish.

Dragonflies are powerful predators as adults. Remember, it is as larvae that the bulk of their eating and growing is performed and the larvae are usually the ecological significant predator. As a child, I kept dragonfly larvae in a small aquarium and can vouch for the fact that they eat many aquatic insects and even small fish! There are two sub-orders of Odonata: anisoptera (dragonflies, Figures 28-30) and zygoptera (damselflies Figure 31).

The usage of the term dragonflies to refer to the anisoptera is not universal. When outside North America, the term dragonfly refers to all Odonata. Adult anisoptera will typically hold their wings flat when at rest. The hind wing is wider than the forewing, and their eyes typically touch or are in close proximity on the head. Adult zygoptera will typically hold their wings over the back when at rest. The hind wing and forewing are similar in shape. The eyes are widely separated on the head. Many people think zygoptera are “baby dragonflies” and some people think the sting of a dragonfly will kill you. These are more examples of insect myths. Dragonflies are typically fast fliers and damselflies are typically very



Figure 30: *Cordulegaster dorsalis*, a showy and widespread dragonfly that had not been noticed in Idaho until recently.



Figure 31: *Argia vivida* in the Sawtooth NF note the mites on the thorax.

maneuverable and can hover. All adult Odonata can be recognized by large eyes, which occupy most of the head, small bristle-like antennae, chewing mouthparts, four elongate wings, and a long, slender abdomen. The legs are not designed for walking but for perching and grasping. The larvae have a unique hinged lip that can be thrust out, like a basket, to capture prey items.

## Plecoptera

The Plecoptera are the trout of the insect world. They are most common where freshwater is cold, clear, and delicious. Trout anglers know these insects as stoneflies. They plan vacations based on adult hatches (when fish gorge upon them) and quiver when they speak of about “good hatches.” Turning over rocks in a clean, cold mountain stream will acquaint you with the flattened, often brightly patterned, predaceous nymphs (larvae). Six strong legs tightly grip the rock; two antennae up front, two cerci on the back end, and gills along the thorax should allow you to identify the nymphs. The adults may superficially look like roaches, but lack the hooded pronotum. Another good clue that Plecoptera are about is the abundance of adults you will find when you are near the water. These animals are important indicators of water quality. Idaho is blessed with many healthy stoneflies populations. A visit to a local fly shop will often give you a good idea, which species are hatching, from which streams.

## Orthoptera

Insect taxonomy is always in flux as our understanding of the animals changes. The order Orthoptera is a perfect example of this process. The old Orthoptera referred to as the straight wings (*ortho* = straight, *ptera* = wing) included many members: mantids, stick insects, cockroaches, crickets, etc. The new, improved understanding of the order, emphasizes jumping abilities and those crazy hind legs; which leaves the grasshoppers, crickets and katydids as the only members of the order. Orthoptera have a simple metamorphosis.

- *Grasshoppers (multiple families)* - Grasshoppers (Figure 32) are the Orthoptera with short antennae. Antennae length may seem to be a small issue, but the grasshoppers sing, mate, hear and lay eggs differently than the members of the Order with long antennae. Grasshoppers are familiar, day-active, mostly vegetarians. Grasshoppers eat a variety plants. Some can be crop pests, others eat weeds, and others eat native plants that may be problematic for ranchers (e.g. rabbit brush). Grasshoppers often have brightly colored hind wings in addition to their strikingly colored and patterned bodies.



Figure 32: Recent hatch of grasshopper eggs.

Many Idaho butterflyers refer to the grasshopper *Dissosteira carolina*, as the “Mourning Cloak Mimic” because it looks a lot like that butterfly when in flight. The front wings, tegmina, are shown in the above introductory materials. The hind wings fold accordion-like under the tegmina when at rest.

Because these insects are defoliators and can cause significant injury to agricultural crops, pastures and rangelands, many resources exist to monitor populations, such as <http://www.sidney.ars.usda.gov/grasshopper/Handbook/intro.htm>. The Idaho State Department of Agriculture has a grasshopper and Mormon cricket control program and conducts monitoring of grasshopper populations within the state. One interesting tidbit about grasshoppers, they are often considered wasteful-feeders because they because they tear off more food than they actually eat, leaving a mess on the ground. They may eat as little as 25% of what they clip from plants – meaning 75% is wasted – or if you prefer, made available to other organisms.

- *Crickets and Katydid*s (multiple families) - The members of the order Orthoptera with long antennae are as interesting, if not more so, than the grasshoppers. The songs of crickets and katydids are just as much a part of summer as the songs of birds. It is true that crickets and katydids change their songs in response to temperature, but it is easier to use a thermometer to tell temperatures than to count the number of chirps per minute and do the math. A great website is Singing Insects of North America (<http://buzz.ifas.ufl.edu/>) where you will find recordings, links, references, and other insect song related items. Adult females of this group have obvious ovipositors such as shown on the tree cricket (Figure 33).



Figure 33: Tree Cricket

A favorite cricket is actually a shield-backed katydid, the Mormon cricket, *Anabrus simplex* (Figure 34). Whether you view this creature as a traffic hazard, danger to alfalfa, or a majestic component of Idaho’s rangelands depends on your point of view, but the spectacle of several adult Mormon Crickets per square foot as far as the eye can see and dominating the soundscape cannot be denied. Just as all Idahoans should go watch Greater Sage-Grouse on the leks, all Idahoans should spend some time in a Mormon cricket swarm – it is a special part of our little slice of heaven.

These critters played a big role in Mormon history. In 1848 Mormon, crickets devastated their farmland. Sea gulls moved in and had an “all you can eat buffet” of Mormon crickets. The Mormons considered it the “Miracle of the Gulls” and erected a monument of two gulls in the Temple Square in Salt Lake City. We were searching for Mormon crickets, in the Bennett Hills area in 2006 (Figure 35).

When we topped the hill, the sky was white with ring-billed gulls. I remembered the aforementioned story and knew we had arrived! The road was not covered as anticipated. When we got out and looked around, the vegetation was black, covered with Mormon crickets. The gulls were not saving any farmland, so they were not miracles in Idaho but they did make the swarm easy to find!

The Jerusalem Cricket (Figure 36), also called the potato bug, is a native to the western United States, along the Pacific coast and into Mexico. Its face is thought to resemble that of a human and, as a result, it has many common names like cara de niño (child’s face), old bald-headed man, and my favorite, Niño de la tierra (Earth Child). The Navajo people called them wó see ts’inii (skull insect). Regardless of its many names, it is not a true cricket and definitely not a bug. These animals live underground and primarily, feed on decaying roots. They have a song, but it is not chirping sounds like other Orthoptera, it beats its abdomen on the ground like a drum. They also make a hissing type noise by rubbing their legs on their abdomen. It is thought that this is done to frighten potential predators.



Figure 34: Two different color morphs of Mormon crickets (above).



Figure 35: Sea gulls feasting at Mormon cricket swarm.



Figure 36: Jerusalem Cricket

## Blattodea

Popular wisdom has it that cockroaches (Figure 37), a 300 million year-old order, will be around, pretty much unchanged, long after humans have poisoned themselves out of existence as a species. Roaches are primarily tropical, but I was lucky enough to live a few months in a Twin Falls motel that was blessed with a thriving population of these nocturnal ambassadors of tropical climes. Roaches are identified by the overlapping wings, hooded pronotum, and a characteristic roach smell. In addition, roaches can be incredibly fast!

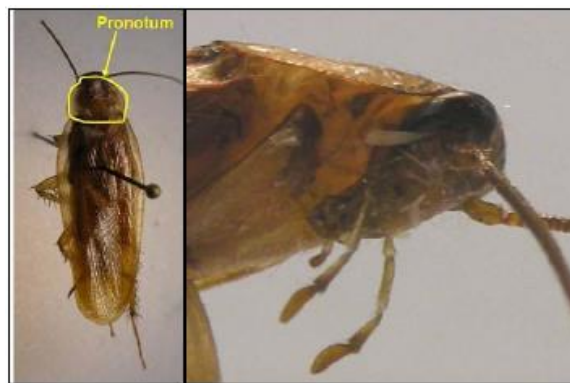


Figure 37: Adult roach (eastern species) and a close up of the head, which is concealed by the pronotum.

Most roaches prefer to live outside in trees, but when conditions are not optimal (i.e., too wet, too cold, too dry, etc.); roaches seek refuge in our homes. Most species do not want to be in your home and are only temporary residents. They will typically leave when their outdoor habitat gets back to normal. There are, however, species like the German cockroach, an introduced pest from Asia, that has evolved to co-exist with humans and are pests in the true sense of the word. Even though they seem gross, they are actually fairly clean animals – that is, as clean as their environment. If a household is dirty, the roach will also be dirty and is likely to spread germs throughout the house. They can also pose other health risks. Some people are allergic to them, especially asthmatics.

The entomologically aware naturalist is not limited to enjoying exotic roaches in their home. There are native, wild cockroaches that live primarily in rotting wood or under bark and can be important nutrient cyclers. These roaches will look very similar to the household roach and reflect the beauty of a very successful body plan!

## Mantodea

In Southern Idaho, the Praying Mantis (Figure 38) can seem to be everywhere in late summer. We have even found adults and egg cases up on Lucky Peak at the Hawk Watch site. The egg cases are a tannish, hard, Styrofoam-like blob. They overwinter in the egg cases, and in spring, baby mantids hatch looking like and wingless adults and immediately begin eating each other.



Figure 38: Praying mantis, Buhl, ID

It is true that the female eats the male's head after mating. Some writers even say this is necessary for successful copulation. Mantids are amazing predators. There is a YouTube video and a Birdwatchers Digest article about Praying Mantises taking hummingbirds as prey! The Praying

Mantis, a successful, introduced species, is a favorite of children and considered very beneficial by gardeners. Introductions are continuing and mantis egg cases are available for purchase via garden supply stores and the internet. The impact of the introduced species on its prey and native mantids is understudied and not well understood.

## Dermaptera

Earwigs (Figure 39) are another primarily tropical group that has some representation in our area.

Earwigs are sexually dimorphic, but the large cerci (a.k.a. pinchers) and short elytra are exhibited by both sexes. The introduced European Earwig, *Forficula auricularia*, is the most commonly encountered and often massively abundant earwig in Idaho. Earwigs are omnivorous, but the introduced European earwig has a discriminating palette and is able to find the best vegetables in the garden.



Figure 39: Earwig

## Isoptera

*Some primal termite knocked on wood  
Moreover, tasted it, and found it good!  
That is why your Cousin May  
Fell through the parlor floor today. "The Termite" - Ogden Nash*

Isoptera, the Termites, share a common ancestor with roaches and Mantids and are ambassadors of more tropical climates. The poem above is most likely what one thinks about when it comes to termites – damage to buildings, or indirectly, a dead, but standing, infested tree weakened to the point it falls on a home (Figure 40). Termites are best known, and hated, for the damage they cause to our homes as well as other structures constructed of wood. In our climate, you will not see many termites running around on the soil surface because most species of termites are subterranean (i.e., live underground), but you may see evidence of their activity. I have found termite colonies associated with buried wood a couple times in the South Sawtooth National Forest. These wild termite experiences were very



Figure 40: Termite damaged tree

surprising but involved small, white insects that were underground. They will not ever be the sole reason for a “Watchable Wildlife” site. As colonial insects, they have some phenomenal capabilities and an amazing symbiotic relationship with cellulose digesting bacteria. These critters are often confused with ants. Termites have straight, bead-like antennae and ants have elbowed antennae. Winged termites have wings of the same size. Ants have hind wings that are smaller than the forewings. Termites do not have a waist. Ants have a narrow waist. They also have different metamorphosis types where baby termites look like the adults and ants undergo complete metamorphosis where adults and immatures look different. A remarkable fact: Queens live for 25 years or more and lay as many as 60,000 eggs in her lifetime!

### Thysanoptera

Thysanoptera, or Thrips, (Figure 41) are tiny insects that are a little bigger than the size of the dash at the end of this sentence: -. Thrips are strange little guys with weird metamorphosis, with two non-feeding instars (stages): pre-pupa and pupa. Its metamorphosis type is incomplete metamorphosis and was not previously discussed due to the complexity.



Figure 41: Thrips adult

Thrips have a unique wing type that resembles a feather (Attachment 2). They may also be recognized by their characteristic feeding damage on plants. They have a unique mouth that rasps away epidermal layers of the plant tissue and then sucks up the plant juices. It is often referred to as a sucking-rasping mouth type and it resembles a bird's beak. Thrips are so small that their feeding destroys individual plant cells, but leaves the cell walls intact. You should key into the empty cells when looking for thrips damage. Because thrips can occur in great abundance, they can be economically important. If you want to find thrips, take any flower in bloom, shake the blossom over a white piece of paper and look for moving “dashes.” If you have a microscope or a hand lens, you will likely discover the moving “dashes” are thrips. Thrips is both the singular and plural word form. You can have one thrips or 10, 000 thrips!

### Hemiptera

Hemiptera is a group of insects that have undergone a taxonomic restructure recently. Hemiptera previously housed the “true bugs” and Homoptera housed aphids, hoppers, scales and others. Now, both Hemiptera and Homoptera are Hemiptera with three sub-orders, Heteroptera (true bugs), Auchenorrhyncha (hoppers and cicadas), and Sternorrhyncha (aphids, whiteflies, and scales) (Figure 42).

Placing the two former Orders into one has made this one of the most diverse Orders in Class Insecta. The decision to place all these insects into one Order was based on their mouthparts (piercing-sucking, previously discussed). There is a difference though, some Hemiptera have mouthparts that arise either from the front of the head (Heteroptera) or from the back of the head (Auchenorrhyncha and Sternorrhyncha). Where the mouthparts originate was the artificial division of Hemiptera and Homoptera prior to them being merged into one Order.

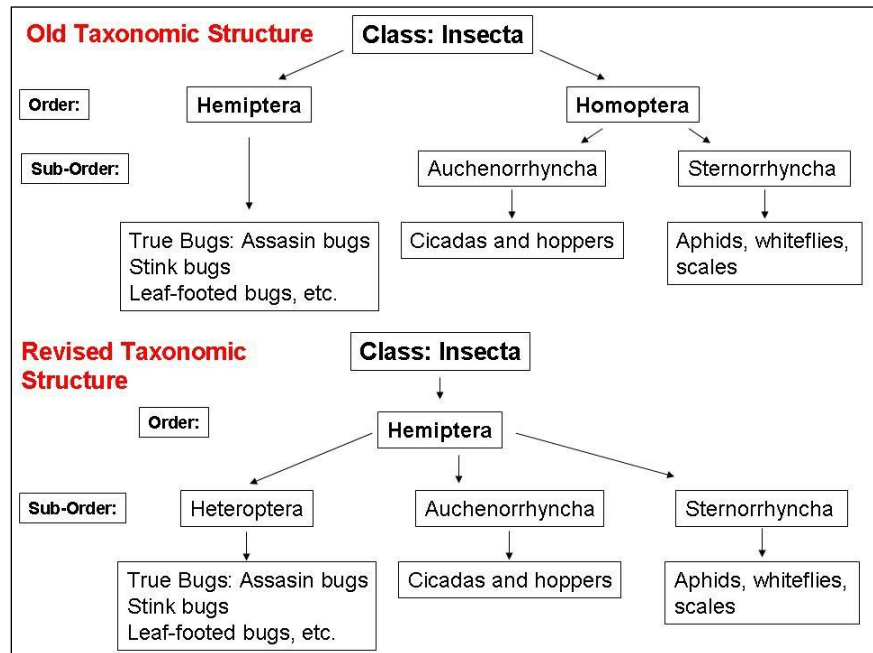


Figure 42: Flow chart describing the revision of orders Hemiptera and Homoptera

### Lygaeidae (Seed Bugs)

Monarch Butterflies (our State insect) are not the only reason to plant milkweeds in your garden. If you are extremely lucky, your milkweeds will support a colony of milkweed bugs (Figure 43).

The beautiful orange and black milkweed bugs (there is more than one species) are members of the family Lygaeidae, and they will feed on the juices of your milkweeds. As you might guess, an orange and black colored milkweed feeder is a distasteful meal for most predators – just like another orange and black, bad tasting insect – Monarchs. The Lygaeidae used to be huge family, but recent taxonomic shifts have split it into ten families leaving the Lygaeidae with about 75 species in North America.



Figure 43: Milkweed bug

### Water Bugs (Multiple Families)

The families Belostomatidae and Gerridae are two of many families of Hemiptera associated with water in Idaho (Figure 44).

Given the importance and diversity of water resources in Idaho, it is recommended that a serious student take the time to learn these and other families of aquatic bugs. Occasionally, a Belostomatid (Water Bug) is found in the hatch



Figure 44: Belostomatidae adult and close up of its piercing mouthpart (left, center) and a water strider (right).

houses of the commercial trout farms in the Hagerman Valley.

The Belostomatid feed on the abundant supply of young trout. The hatch house technician often learns that, when mishandled, these creatures can inflict a painful bite – just look at its thick, broad proboscis. This group of insects represents the “single fathers” of the insect world. Females lay eggs on the backs of males and it is the responsibility of the males to protect and care for his progeny. They are among the few insects that exhibit male-parental care. The Gerridae, or water striders, are ubiquitous wherever water slows down and is still. These insects are a magnet for small children and hours can be spent watching, catching, and chasing these amazing predators, which are exquisitely adapted to life on the interface between air and water.

## Pentatomidae

The stinkbugs, or Pentatomidae, are a trophically diverse group (some are predators, some are generalist plant feeders, and some are specialized plant feeders) that all appear physically similar (Figure 45).



Figure 45: Two different species of western stink bugs.

The five segmented antennae (penta = five) is found in all members of the family, but the basic family resemblance is uncanny. Given time, you will know these bugs on sight without counting antennae. Many insects produce an odor. Some insects produce stronger and/or more disagreeable odors. The reason stink bugs are so named is they are the most commonly encountered of the stinking insects. That said a collection of the stink from stinkbugs was used to flavor a beer brewed specially for a recent national meeting of the Entomological Society of America. This flavorful, thirst quenching, healthful, and piquant brew was enjoyed by many and pronounced delicious, by some. During the auction, a single 12 oz. bottle sold for \$30! Stinkbugs, due to the wide trophic diversity among species, can be beneficial or detrimental to human goals. Regardless, when you look into their little cross-eyed

faces, they are just so darn cute it melts your heart. Even though some farmers may not agree, the world is a better place because we can share it with stinkbugs.

## Cimicidae

I have been studying insects for almost 12 years, but it was not until a couple of years ago that I saw my first bed bugs. In Idaho, I had extension responsibilities, and received a specimen from Lemhi County. In addition, a pest control operator visited my office asking me to verify his finding. Both cases were the dreaded bed bug (Figure 46). Upon visiting with the man, he informed me that he has treated one home in Twin Falls, and knows of three other infestations in the Magic Valley area. Bed bugs are not an overwhelming problem to date (2008), but they are likely to become one...and could become a bad one.



Figure 46: *Cimex lectularius*, the Bed Bug, posing with a penny to show size. Twin Falls, ID, 28-Feb-2004.

Bed bugs were virtually extinct in the mid to late 60's in the United States but since 1998-1999, there seems to be a resurgence of these creatures. A nationwide survey conducted in 2005 by a group of entomologists revealed only about 30% of pest control companies treat for bed bugs but 67% of all surveyed companies report they have had an increase in bed bug calls in 2005 compared to 2004. So what exactly are bed bugs? They are small nocturnal insects that typically feed on animals while their victim is sleeping. Their bite is considered painless. Most people do not even feel the bite. When feeding, they inject their saliva into the victim which can cause an allergic reaction in some individuals that results in a welt that may itch (welt and itch severity varies). Reactions can occur in as little as one hour following the bite or may not appear for three or more days.



Figure 47: *Cimex lectularius*, the Bed Bug.

These blood feeders (Figure 47) are not like mosquitoes that require a blood meal to produce offspring. Bed bugs only feed on blood of mammals and birds. The only positive side to these insects is they are NOT known to transmit any human diseases.

The top insect has fed recently. The bottom insect has not. Twin Falls, ID 28- Feb-2004. Why are they becoming a problem all of a sudden? No one is sure the exact cause. Some thoughts on the subject include: insecticides that were once used heavily in the 60's and 70's are starting to break down and are no longer effective; resistance has developed to current

insecticides; and international travel. There are no data available to support the ideas associated with insecticide, but there is circumstantial evidence associated with travel. It appears that the majority of initial outbreaks were associated with metropolitan cities and subsequent infestations are in smaller, less metropolitan areas. People visit big cities, stay in a hotel, and unknowingly pack up some unwanted souvenirs of the vacation.

What do you look for? If you wake up with unexplained red bumps, this is an indicator that something may be going on but does NOT mean you have a problem. It just means since bed bugs are on the rise, it is something to consider. Pest control operators have said the most common places bed bugs are found are in/on the mattress and box spring, on headboards, along baseboards, in carpet, and cracks and crevices of furniture. Some of the more uncommon places were inside cars, radios and other electronic devices, the kitchen, a showerhead, on curtains, and on a person. These critters are small, flat and cryptic and can hide almost anywhere so a thorough inspection is essential.

What can be done about bed bugs? Since these pests virtually did not exist for nearly 40 years, research on bed bugs is lacking. The first and foremost thing to do is a thorough inspection. It is also advisable to have a pest control professional assist. Homes often have to be treated with an insecticide that causes the homeowner to be at greater risk to insecticide exposure. Therefore, it is better to let a professional handle this pest. Of all situations involving pesticide misuse, homeowners are usually the number one offender. It is one thing to apply a 5X rate to your roses accidentally, but to apply a 5X rate to your bed that you sleep on is another. Insecticides are poisonous and can make people sick or can be deadly. Due to the nature of this insect and its relationship with humans, it is best to contact a licensed pesticide applicator for this critter. Because these insects are cryptic, hiding in the smallest of nooks and crannies, control is hard to achieve.

The previously mentioned survey also mentions that only 6% of infestations were controlled successfully by only one visit. The majority of infestations required 2-3 visits and 11% requiring 5-6 visits. There are non-chemical options. This can be discussed with a professional so that he/she can work with you to train you what to look for and where. While we may not like the thought that we are sleeping with blood feeding insects, it is becoming more of a reality. The best defense is to minimize clutter around the house (places for them to hide), avoid getting used furniture because you do not know the reason someone is getting rid of it, and when traveling, check behind wall mounted headboards as they are the number one bed bug hiding place in hotels. Remember, sleep tight and do not let the bed bugs bite!

### **Reduviidae**

The nasty-looking beak perched on the front of the head (Figure 48) characterizes assassin bugs, or the Reduviidae.

The beak is designed for punching through other insects exoskeletons like a child punching a straw into a juice box. There are accounts of Reduviids with painless bites, but that is not our experience. In Idaho, you will most likely experience excruciating pain from defensive chemicals and/or digestive enzymes associated with the bite. Many assassins are brightly colored, perhaps to advertise the danger inherent in handling them. A budding Idaho entomologist would not touch any Hemipteran due to extremely painful experiences with Reduviids. I hope that you will be lucky and avoid being bitten as you study these fascinating and important creatures.

### **Cicadidae**

Cicadids (Figure 49) are another insect famous for their singing ability. They can be extremely long lived, the 17 year periodicity of adult emergence of *Magicicada* (what an appropriate name), reflects a 17 year larval period. In the juniper woodlands of Southern Idaho lives a cicada that first feeds on the outer branches of the juniper tree, then drops to the ground for a couple years of root feeding, and finally becomes an adult to fill the juniper-scented summer days with song. The red, dying outer branches of the juniper trees that result from the feeding of the freshly hatched nymphs are very distinctive and can be numerous. Big sage (*Artemisia tridentata*) also has a cicada species.

### **Cercopidae**

Spittlebugs, or Cercopidae, are small but often beautiful as adults. As nymphs, different species feed on different plant species encased in a frothy “spittle” that results from fluid voided from the anus mixed with mucilaginous secretions from epidermal glands. From within this living room of their own making, the little spittle bugs can



Figure 48: Immature assassin bug with lightning bug prey. Not an Idaho photo.



Figure 49: Cicada adult at Jim Sage Mountains (top) and exuvium from an immature cicada before the final molt to adulthood at South hills (bottom).

feed in privacy and safety. The spittle can be a conspicuous component of meadows as shown in Figure 50. The spittle can survive rains and heavy dew, and probably protects nymphs from desiccation, predators, parasites and other unfavorable environmental parameters.

## Aphidae

There are about 4,400 species of aphids. Aphids (Figure 51) utilize a variety of plants, parts of plants, life histories and mating systems.

The typical rose aphid is small, pear-shaped, soft-bodied insect, with long legs and antenna, and a pair of short tubes, called cornicles protruding from the hindquarters. These cornicles produce the chemical clouds by which aphids communicate. Some entomologists will tell you that the typical rose aphid will feed on blackberries, apples. Other rose family members other entomologists will tell you each plant has a different species of aphids. Most adult aphids are wingless and female. Winged adults appear in spring and fall, or when there is a declining food source that signals a need to move a colony. Although aphids are sometimes found singly, they are more often found in dense clusters on the tips of new growth. Small numbers of aphids do little damage, but as numbers of aphids increase, stunted shoots, loss of vigor in new growth, less production of blooms and virus transmission are problematic for the plant. The aphid wants sap, the nutritious lifeblood of the plant. The aphid targets soft, growing tissue where nutrients are dense. Aphids force their mouthparts into the plant tissue with their bodyweight. The aphid then injects chemicals into the plant to improve the flow of nutrients, beginning the chemical warfare between the plant and the aphid. A healthy plant responds by sending tannin glues and reducing flow of nutrients to the "leaking" area. The tannin seizes up proteins within the aphid, slowing its pumping. Aphids attempt to get around the plants defenses by picking on the weaker plants that are environmentally stressed. Once a successful feeding site is found, the aphids cluster together more closely, overwhelming plant



Figure 50: Spittlebugs on *Ranunculus* (top), spittlebug adult (bottom).

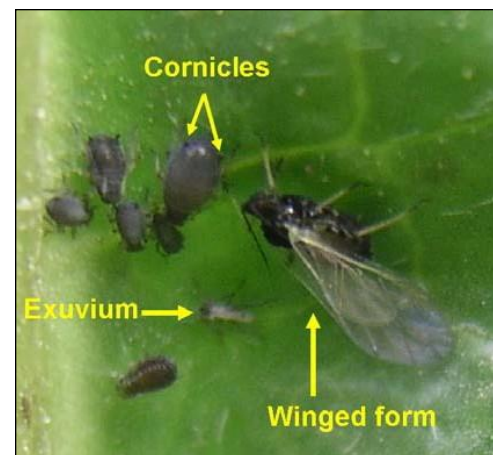


Figure 51: Aphids

defenses. Teamwork is great, but as numbers build so does the potential for discovery by predators. The clustering is regulated through communication by chemicals injected into the plant and/or gases released through the cornicles. Interestingly, aphids can detect the chemical presence of ladybugs (a major predator) and are deterred from feeding where ladybugs have been.

Feeding aphids do not move when disturbed because of the inserted feeding tube. This makes them sitting ducks for predators, including ladybugs, flowerfly larvae, wasps and lacewing larvae. Aphids rely upon sheer numbers, speedy reproduction and a few chemicals for survival. Ants can become involved in the predator/prey relationship by “farming” aphids for “honeydew” excreted by the aphids (Figure 22). Like any good farmer, the ants protect their livestock from predators – a job made easier by the clustering habits described.

In spring, female rose aphid nymphs will hatch from eggs that have overwintered on canes and begin to feed. Over the next ten days, depending on temperature, the nymph molts four times before becoming an adult. During most of the season, most aphids reproduce asexually (parthenogenesis), with adult females giving birth to live nymphs (that are already pregnant), as many as 12 per day. Each newborn is ready to produce young of its own in ten days. Now you know why things can get so bad so fast.

In late summer and early fall, female aphids begin to produce male and female aphids that hold eggs instead of giving live birth. Eggs require fertilization by the male, after which the female lays eggs that will overwinter for the next season. Aphids get to your plants by flying, or more accurately drifting. Poor aerodynamic design and fuel problems (sap is heavy) limit flight time and distance. While in flight, the aphid has a sensing device that detects the distinctive infrared signal of a green plant in distress. When a suitable host is detected, it is communicated to other nearby aphids, and all drop to the intended host and the miraculous cycle begins anew.

## Neuroptera

Neuroptera encompass many insects that look similar to Odonata (dragonflies and damselflies). They have long slender bodies and large membranous wings, but they have long antennae (Odonata have short setaceous antennae). Neuroptera also have smaller eyes than the Odonata. The wings of Neuroptera have more veins than Odonata and are typically held roof-like over the



Figure 52: Brown lacewing adult (left) and grass with lacewing eggs (right).

abdomen.

- *Chrysopidae and Hemerobiidae* - Lacewings (Figure 52) are delicate, beneficial insects. They are fierce predators of aphids, and eat small eggs of other of insects. There are two families that look similar, the brown (Hemerobiidae) and green (Chrysopidae) lacewings. They are primarily differentiated by their colors. They lay eggs that look like little white footballs on hairs stuck to plant leaves.

- *Myrmeleontidae* - When I was a child, my father showed me a small hole in the dirt and then stuck a piece of pine straw down in the hole and proceeded to say, “Doodlebug, Doodlebug, come out, come out – your house is on fire.” Then a prehistoric looking creature came out of the hole. It was an ant lion. As larvae, these insects live underground, and wait for ants or other small insects to crawl over the hole. The insect above ground disturbs the dirt causing some dirt to fall on top of the ant lion larva in its hole. The ant lion pops out of the hole and captures the prey. An adult ant lion is shown in Figure 53.



Figure 53: Antlion adult

- *Mantispidae* - Mantispids are unique, (Figure 54) because they look like baby preying mantids but with wings.

They have the raptorial front legs of a praying mantis, but have membranous wings instead of leathery/parchment-like wings. Larvae are parasitic on eggs sacs of spiders. There is also an unusual Mantispid in Idaho that, literally, looks like a cross between a wasp and a praying mantis. It is striped yellow and red with a wasp-like abdomen, but it has raptorial front legs.



Figure 54: Wasp mimicking Mantispid

- *Raphidiidae* - Hee-yaw Partner! In North America, these odd fellers are only in the West. The snakefly reminds one of the elusive Jackalope, except that snakeflies are REAL! The larva feed on invertebrates under loose bark and the adults are predators. The snakefly in Figure 55 is a female – the weird,



Figure 55: Snakefly

curved ovipositor is plainly visible.

## Coleoptera

The Coleoptera, or beetles, are a huge group with many species. Weevils, a single type of beetle, may contain 10% of all species (all life forms!) known to this planet. The defining characteristic of this holometabolous order is the hard, protective forewings called elytra, that when they meet, make a straight line down the middle of the insect's back. Even flightless beetles possess this trait. In some beetles, the elytra are reduced but still meet in this characteristic manner.

- *Carabidae* - The Carabidae or ground beetles are important predatory insects. This is a very large family of mostly beneficial insects (~2600 species in North America) although a few do feed on plants and many will feed on seeds when prey is not available. The Carabidae, as currently understood, contains insects that were formerly placed in other families, such as, the Cicindelidae or tiger beetles. Tiger beetles (Figure 56) have the distinction of being “honorary butterflies” and as such are well liked and accepted readily onto conservation lists.



Figure 56: *Cicindella arenicola*

Tiger beetles tend to inhabit open, disturbed habitats. Therefore, it is not surprising that Idaho's two major sand dune systems: Bruneau and St. Anthony Sand Dunes both support endemic tiger beetles known only in Idaho! Because of the human interest in the tiger beetles, study of these insects is greatly facilitated by the presence of many good books. Northern Idaho is blessed because John Acorn's Tiger Beetles of Alberta covers the fauna well. The South will be best served by A Field Guide to the Tiger Beetles of North America by Pearson, et al.



Figure 57: Weevil from Palouse Prairie area.

- *Curculionidae* - There are more species of weevils (Figure 57) than there are vertebrate species living on the planet today. Even though these beetles can have very long, thin snouts, at the end of

the snout are the chewing mouthparts of a beetle – however tiny they may be.

Weevils can be pests of economic importance and some species have lifestyles that intimately associate with fungi that they vector from plant to plant. Yet, when an invasive and noxious weed is threatening, we often turn to the weevils to put on super hero cape and tights work for us as biological control agents of the problem species. Weevils, in addition to the aforementioned snout, also possess characteristically clubbed and elbowed antennae, and a sturdy and robust exoskeleton.

- *Scarabaeidae* - June bugs, dung beetles, chafers are all scarabs. This group has individuals that are the largest insects on the planet (although, the big guys aren't found in Idaho). As larvae, they all have that characteristic "C" shaped white grub morphology. The scarab shown in Figure 58 feeds on sagebrush roots as a larva.



Figure 58: *Paracotalpa granicollis*

We have found adults to be common in big sage stands in early summer. This beetle is sagebrush obligate just like the Greater Sage-Grouse – the difference is up until now you probably did not know it existed! Scarabs are also responsible for the rising and setting of the sun. According to the ancient Egyptians, this myth stems from the dung beetle forming perfectly round balls of dung and rolling them. The Egyptians saw the sun as a perfectly round ball that was rolled from one side of the sky to the other.

- *Dermestidae* - Dermestid are a very important group as they clean up the dead stuff that would be piled high and stinky if we did not have their help. Conservation Seeding and Restoration had a colony that was very popular with children at fairs, schools, and other public venues. These beetles also have a fondness for your insect collection and clean up all those dead insects, if the collection is not cared for correctly. We know of a pickup truck, used for backlighting, that develops a dermestid colony every summer. The dermestids kept the truck smelling fresh and clean. Dermestids can also be household pests feeding on: carpet, stored foods, dog food, etc.

Dermestids are also the Crime Scene Investigation bugs (C.S.I.). These critters, along with maggots and others, can be useful in predicting time of death in homicide cases. Therefore, they are useful to law enforcement agencies. Researchers in some of the

southern states have examined them in terms of poaching of wildlife cases. Therefore, poachers beware. In the future, these critters may help put illegal hunters behind bars.

- *Coccinellidae* - Lady bird beetles (a.k.a. ladybugs) are one of the most recognizable insects. They are characteristically red with black dots on the wings. The larvae are alligator-shaped. Both adults and larvae (Figure 59) are voracious predators of aphids.

An Australian lady bird beetle was the first insect used as an introduced, biological control agent for control of an introduced scale. Additionally, multi-colored Asian Ladybugs were brought to the United States for as a biological control agent. However, it has become a pest in households because they move into homes during winter, because they, too, like warm places during the winter. Rather large populations can establish themselves in homes and offices. A concern is that they may be displacing our native ladybug species.



Figure 59: Lady Bug adult and larva.

Another thing that many people may not be aware of is when it comes to lady bugs...if disturbed or if they feel threatened – they will bite. They do not hurt but you will know that you were bitten!

- *Gyrinidae* - Whirligigs are the black, oval beetles swimming en mass on the surface of quiet waters. The adults are scavengers and feed on insects that have fallen into the water. The larvae are aquatic predators. The easiest way to identify these guys is when they are alive in water. They are known to whirl around in circles rapidly, hence their common name, whirligigs. Figure 60 captures the circular ripples in the water due to this behavior. The most distinctive morphological characteristic of this family is the pair of compound eyes situated for vision in air and a pair of compound eyes situated for vision under the water surface. When you live on the water-air interface, you may benefit by tracking both. According to Borror and DeLong, 56 species of Gyrinids live in North America.

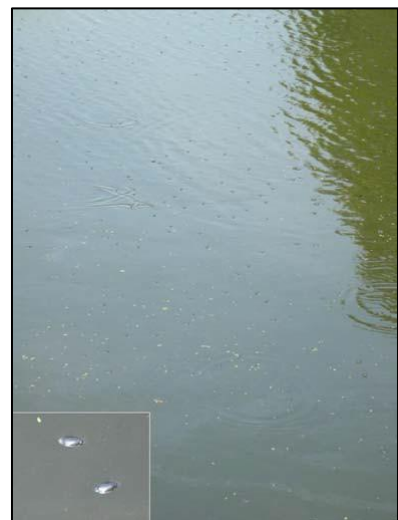


Figure 60: Water beetles

- *Silphidae* - The carrion beetles (Figure 61), or Silphidae, could be named for their diet or the way they smell. They are large and colorful. [www.bugguide.net](http://www.bugguide.net) covers the group pretty well.

Be aware that there is an endangered member of the family. You will want to be certain of the species if you choose to collect, as killing an endangered species is illegal.

Some carrion beetles are called burying beetles because they will find a small dead bird or mammal and bury it. (No, they are not called “buryin” carrion beetles.) A female will lay eggs in the soil. Larvae will hatch and begin to feed on the bird or mammal carcass. Another interesting fact about this insect group is that burying beetles exhibit parental care. Adults will feed larvae and protect their children’s food from other carrion feeding insects.



Figure 61: Carrion beetle

This group is mentioned because they appeared to have a population increase in Idaho in 2006. Carrion beetles need carcasses for their larvae. Small bird carcasses are ideal for this group. The first year West Nile Virus (WNV) was widespread in Idaho was 2006, and WNV killed many songbirds. The beetles likely responded to the abundant resource. Unfortunately, data do not exist to back up this observation, but the beetles seemed to be everywhere during the 2006 insect season.

## Wood Boring Beetles

- *Bark Beetles* - Females make a tunnel between bark and lay eggs. Larvae hatch and feed on tissue behind the bark creating elaborate tunnels called galleries that can eventually girdle the tree. Adults emerge and leave pinhead-sized holes in the bark that gives the bark a "shot hole" appearance. Mountain pine beetles are problematic in pine forests throughout the west. They are small insects that create noticeable damage. (Figure 62). They prefer ponderosa and lodgepole pines over

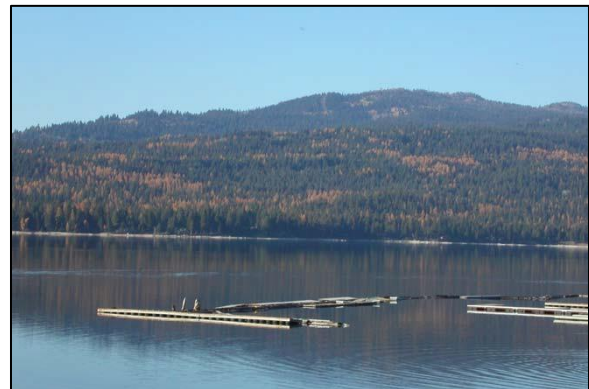


Figure 62: Mountain pine beetle damage to forest.

pinyon pines. These beetles are known to attack trees that are already stressed. Once a couple of beetles locate a good source of trees, they send out a signal to other beetles and invite them to a party, which can do a lot of damage to the trees that host them.

- *Buprestidae* and *Cerambycidae* - These beetles lay eggs singly or in groups on the bark or in crevices in the bark. The eggs will hatch and move into the tree to overwinter as small larvae or they overwinter as eggs and hatch in the following spring. Young larvae mine the inner bark or wood creating tunnels that are flattened, usually oval in cross section, and gradually enlarging as the larva increases in size (Figure 63). Mines are tightly packed with fine sawdust. Upon exiting the tree, flat-headed borers leave a characteristic oval/elliptical shaped hole in the bark and long-horned beetles leave circular holes.



Figure 63: Damage to tree from wood boring beetles.

Although they can devastate a tree, these can be some of the more beautiful beetles (Figure 64). The other common names for the flat-head borers are jewel bugs and metallic wood boring beetles. Their shape resembles a bullet and they are often brightly colored and/or metallic colored. Long horn beetles are aptly named because their antennae are at least half as long as their body, but are more often the length of the entire body or longer. These are often brightly colored or have marked elytra.



Figure 64: Herbaceous milkweed long-horned beetle (top) and Metallic wood boring beetle (bottom).

- *Meloidae* - Blister beetles (Figure 65) are necessary to mention because of the secretions they produce. They are in the family Meloidae and they secrete a juice, cantharadin, from their joints. When cantharadins contact human skin it burns, and in most cases, one will develop large, somewhat painful blisters (Figure 65). Sometimes, they are brightly colored to warn you of the imminent danger that may result from handling them. However, many are not. A quick general rule is that the thorax is narrower than both the abdomen and head. You may want to



refrain from causing yourself some pain! Eating these beetles while grazing must be problematic for mammalian herbivores due to blistering and swelling of the throat and mouth. Several years ago, in the mid-west, blister beetles were found in hay fed to horses. The beetles caused the deaths of several horses that consumed the blister beetle infested hay. The cantharadin from a European blister beetle is the active ingredient in the famous aphrodisiac, “Spanish Fly.” Beetles were once ground up to make a powder that was then sold for its supposed aphrodisiacal properties.

- *Tenebrionidae* (a.k.a. “Stink beetles”) - These insects, when disturbed, emit a foul odor. It is for this reason that it has been given the common name “stink bug”. (Figure 66). First, beetles are not bugs. The name “bug” technically only corresponds to insects in the Order: Hemiptera. Second, just because an insect emits a foul odor, does not mean it is a stink bug! The correct common name for these insects is “darkling beetle” or a Tenebrionid. Many insects will produce a stinky smell when bothered. It is a defense mechanism. Most animals, including humans, leave these “stinky insects” alone because they do not like the smell. Another interesting bit of information about this family of insects (*Tenebrionidae*) is that they typically have fused elytra and are not able to fly.



Figure 65: Blister beetle adult (top) and the injury they can cause if the cantharadin contacts the skin (bottom).



Figure 66: A darkling beetle often wrongly called "stink bug."

## Mecoptera

The Mecoptera are considered to be closely related to flies and can be recognized in all adult forms by the peculiar head shape and chewing mouthparts (Figure 67). Males will often have a scorpion-like stinger structure on its abdomen. If you are spring skiing, you may see Snow

scorpion flies on the snow. Because of the Snow scorpion flies small size, most skiers do not notice these amazing insects.

### Tricoptera

Tricops, or caddisflies, are favorites of trout, trout fishermen, and architecture students. YouTube (<http://www.youtube.com/watch?v=WQviNYeBb9g>) has videos of caddisflies building their distinctive larval cases out of precious materials. Cases such as these (Figure 68), but made with semi-precious gems, can be epoxied, as a preservative, and made into jewelry. Conversation with one person doing this confirmed that there is no need to harm the larva. They just wait until the caddisfly is done with its case. Cases can be built out of materials other than gemstones or stones for that matter. In addition to their building skills, Tricops are also important indicators of water quality.

### Lepidoptera

The Lepidoptera often function as the “starter drug.” Unsuspecting naturalists will often dabble in butterflies recreationally, only to wake up in the gutter of the Pentatomidae (or other HARD insects) with months of their life just missing! People love butterflies. Butterflies are unique among the insects in that they are almost universally accepted and valued by people. The Xerces Society ([www.xerces.org](http://www.xerces.org)), the premiere insect conservation organization, has a red list of insects of conservation concern with 22 butterfly species and two moth species listed. When one realizes that there are ten times more moth species than butterfly species, one questions why more moths? Are butterflies more delicate? Are more butterflies habitat specialists than moths? No, people just like them more. That makes butterflies a special case in the world of insect



Figure 67: Short-faced Scorpionfly Seven Devils.



Figure 68: Tricoptera larval cases



Figure 69: Caterpillar of Anise Swallowtail

conservation. In addition, butterflies are out, during the day, when people are also out, whereas moths are out at night when we are asleep. Consider how difficult it would be to have a specialized mosquito species listed on the Endangered Species list compared to a butterfly.

The Lepidoptera are holometabolous insects, or insects that go through a four different life stages: egg, caterpillar (Figure 69), pupa (Figure 70), and adult. Lepidopteran caterpillars are ecologically important, because it is as a larva when the bulk of predation occurs and the vast majority of food is consumed. Some Lepidoptera eat strange diets such as turtle shells, hair, or aphids but, usually, if you find a lepidopteran caterpillar, you can assume safely that it eats plants. Some caterpillars will only eat certain parts of certain plants. Others might eat plants within a certain genus, while some (e.g. Gray Hairstreak) will eat almost anything. The tubular mouthparts (proboscis) of the adult limit adult foods to nectar, and occasionally pollen. This proboscis is usually carried coiled between the labial palps on the head. The availability of nectar resources influences adult fecundity (reproductive abilities) in most lepidopteran species. This is why many butterflies are drawn to flowers and the underlying reason butterfly gardening is so popular.



Figure 70: Anise Swallowtail pupa

The difference between butterflies and moths is largely an artificial, human construct. However, butterflies have clubbed antennae and tend to fly during the day. Moths have various other antennal types, and mostly fly at night. Most moths also have a structure called a frenulum, that functions to keep the wings aligned, but you will not see that in the field. Initially, concentrating on butterflies will keep you busy. But, as time passes, you will encounter so many beautiful and interesting moths, you will realize that a butterfly-only avenue of study is like a peanut butter sandwich without the jelly – satisfying, yet without the sweetness.

Two books by Robert Michael Pyle stand out as important resources for Idaho butterflyers: *Handbook for Butterfly Watchers* and *Butterflies of Cascadia*. Armed with these two books, you are ready to begin your quest. If you travel outside of the region, you will want the Kaufman butterfly guide or one of the Glassberg *Butterflies through Binoculars* series. The fact that a butterflyer has more than one field guide to choose from is testimony to how popular these insects are. There currently is no one, go-to source for Idaho moths.

The *Butterflies and Moths of North America* web site ([www.butterfliesandmoths.org](http://www.butterfliesandmoths.org)) offers lists of Lepidoptera documented Idaho counties. Documenting the Lepidoptera in your county is a

worthwhile and engaging activity. Many counties have small lists, not because they are bad habitat, but because no one has looked.

Robert Michael Pyle writes about the beauty of the Pine White (Figure 71) flight along the Payette River and I must concur. This really is a soul-enriching spectacle. These butterflies have a beautiful and graceful flight and are worth seeking out. Spending some late-summer time along the Payette is a treat in itself. Try not to let the butterfly carnage from Highway 55 discourage you. When in bloom, the high mountain meadows throughout Idaho offer very rewarding butterflying and should be sought. The Southern Idaho deserts and shrub steppe habitats are very interesting in springtime when the marbles, Juba Skipper, and Spring Whites are flying. Five families of butterflies are well represented in Idaho: Hesperiiidae (the Skippers), Papilionidae (Swallowtails), Pieridae (Whites and Sulphurs), Lycaenidae (Blues, Coppers, Hairstreaks, and Metalmarks) and Nymphalidae (the Brushfoots) (Attachment 4).



Figure 71: Pine white butterfly

Idaho's moth fauna is also varied and interesting. In fact, there are typically ten times more species of moths in a given habitat than there are butterflies. There are also about ten times more families. A neophyte will encounter: Geometridae (inchworms), Saturniidae (Silk Moths), Sphingidae (Hummingbird Moths), Noctuidae (various names for subfamilys), and Arctiidae (Tiger Moths) (Attachment 4). Many moths will be encountered as caterpillars. The conspicuous webbed nests of Malacosoma (Figure 71) can be inspected to reveal a mass of caterpillars. Tussock moths feed on a wide variety of trees and, in an outbreak year, caterpillars can seemingly be everywhere in Idaho's forests. Idaho's moth fauna is not well documented. A serious student will find great riches. From the day flying beauty of the Arctiid moth Platyprepia, to the night-time Saturniid grandeur of Antheraea, to the Sphingid hummingbird-mimic Hyles, Idaho's moths are fascinating and will greatly repay the investment in time that their study requires. Hemileuca awaits you!



Figure 71: Malacosoma larvae

## Diptera

The Diptera is an order of holometabolous insects defined by the presence of two wings, instead of the normal four found in the other winged orders. The hindwings are actually present, but have been modified into structures called halteres. The common name for this order is flies. You may have noticed that dragonfly, damselfly, and mayfly are one word and that is because they are not true flies. Only true flies have the distinction of having names with two words.



Figure 72: Golden poop eater. *Scatophagidae*.

Fly larva are varied: some are parasites; some are scavengers; some are predators; some are detritivores; and some are herbivores. Physically, fly larvae are usually legless and wormlike creatures called maggots, but some larvae are exquisitely complex in form, such as mosquito and black fly larva. As one might assume, a wide diversity of body types and diet lends itself to exploiting a wide variety of habitats. Many adult diptera are important predators and pollinators. The adult mouthparts are designed for feeding on liquids and the primary food source of numerous families of Diptera is blood of vertebrates, including humans. As a result, everyone is aware of the stable fly, the horse fly, black fly and, of course, the mosquito. Diptera can serve as disease vectors. The spread of West Nile Virus is due to mosquito vectors. Diptera are amazing creatures (Figure 72) with many complex mating rituals and dances – they even exhibit lekking behaviors. Sage grouse are entertaining, but to watch flies strut their stuff is nothing short of amazing. A brief introduction to some of the Diptera follows:

- *Culicidae* - Mosquitoes (Figure 73) are of interest to anyone who has ever spent time outdoors. They are known as the Dipteran family Culicidae to entomologists. Mosquitoes have aquatic larval stages, and adults that are recognized by scaled wing venation, wings outlined with fringe and a long proboscis. Mosquito pupae are more mobile than most insect pupae and can be seen in most still bodies of water.

If you have never seen mosquito larvae and pupae, you can easily do this by putting a bit of yeast and some grass clippings or leaves in a bucket, placing the bucket in a shady location, and



Figure 73: Mosquito

keeping water in the bucket. Eventually you will be able to see wrigglers (the larvae) and tumblers (the pupae) in the bucket at the water surface. Although these are aquatic larvae, they breathe air and must come to the water surface to breathe. If you transfer some of your water and larval and pupal mosquitoes to a clear-sided container, you will be able to enjoy the antics of these beautiful Dipteran larvae. Adding a predator such as an Odonate larva to the container will make your jar of water a Disney true-life adventure! If you see female mosquitoes on the water surface, they are probably laying eggs. It is fascinating to watch any animal lay eggs. The artistically inclined may wish to use the bucket and inhabitants as models for photos and drawings. The scientifically inclined may wish to quantify various aspects of the bucket and find out how different variables will affect the mosquitoes. Mosquito larvae are typically feeders on algae and organic debris but some are predators on other mosquito larvae.

It is true that only female mosquitoes bite. They need protein to make healthy eggs. Not all mosquitoes bite humans. Humans are not the preferential host for many mosquito species. Some mosquitoes feed on birds. Some feed on mammals. Some will feed on birds or mammals. Still others feed on only nectar. It is the mosquitoes that feed on birds and mammals that are most responsible for West Nile Virus.

Humans are abundant and conveniently filled with blood. Therefore, they can be a good blood meal for many mosquito species. Males feed on other liquids, typically plant juices and nectar. Females, when searching for food, will also nectar, if they are not in need of a blood meal for offspring production. In some situations, observations of large numbers of nectaring male mosquitoes would lead one to believe that they may actually be important pollinators.

Differentiating the species of mosquitoes requires a dissecting microscope. There was an Idaho-specific key to adult female mosquitoes circulating around county extension offices during the summer of 2006. Perhaps copies of that document are still available.

- *Chironomidae* - The family Chironomidae is also known as midges (Figure 74). These delicate and ubiquitous insects are often mistaken for mosquitoes. Before you douse yourself with bug spray, check for these characteristics: no scales on wings and no long proboscis. Another characteristic that midges typically have is very long front legs often mistaken for antennae.

If you have ever encountered a large swarm of mosquitoes, it probably was not exsanguinating mosquitoes. It was likely an impressive swarm of midge flies. One such swarm provided learning opportunities about insect numbers for a group of blind students birding at the Minidoka National Wildlife Refuge. At a height of about 50' above our

heads, hundreds of thousands of midges created a ceiling. The children were able to tune into the beating of all those wings that created a terrific level of sound.

Most midges have aquatic larvae, but some will live in decaying matter. The bright red insect larvae you find in the muck at the bottom of the pond are



Figure 74: Midge adult (left) and larva (right).

Chironomids that

have hemoglobin to help them obtain oxygen. It is one of the few insects that has hemoglobin. These larvae can be an important food source for other aquatic creatures. Midges are very specious. We do not know of a key for Idaho midge species.

- *Ceratopogonidae* - The family Ceratopogonidae is known as “no-see-ums” to you and me. For something so small, the bite is huge. Remember, all Diptera feed on a liquid diet as adults. The liquid that no-see-ums want is your blood and biting is how they get it. Many no-see-ums are reported to utilize insects as food sources, sucking hemolymph (i.e., insect blood) from many different insects, including mosquitoes! According to Borror and DeLong, many no-see-um species will not travel far from where the larvae live and moving away a few yards can often alleviate the pain that these flies can inflict. The no-see-ums have broader, more patterned wings than midges and the wings are held flat over the back. The larvae are aquatic to semi-aquatic and have poorly known feeding habits.

In Riggins, the hotels have signs warning patrons not to sleep with windows open, as the screens will not prevent all biting insects from entering. Based on this information, Riggins may be a good place to acquaint yourself with these insects. The Chamber of Commerce will probably be able to assist you with timing your stay.

- *Simuliidae* - By now, you probably have a good understanding that Diptera feed on a liquid diet and blood is a liquid that is very desirable because of rich protein content. The Simuliidae, or Black Flies, can aggressively seek your blood and have been reported to cause deaths (humans and livestock). The larvae live in streams and attach to hard surfaces. According to Borror and DeLong, about 165 species of black flies live in North America.

- *Muscidae* - The family Muscidae is a very large group that can be found almost anywhere. This group includes the housefly and the stable fly. The stable fly is a biter, and unlike most other Diptera species, both sexes feed on blood. The larvae of the housefly feed on filth (excrement and decay). The stable fly larvae feed on rotting straw. The annoying flies coming from the dairies are in this family. The Muscidae vector many diseases and can be vexatious to both livestock and humans.
- *Tabanidae* - At this point, you may feel that Diptera view you as a walking blood source. The Tabanidae is yet another family of Diptera that are more than willing to take advantage of you. You probably know these creatures as deer and horse flies. Females tear your skin and suck your blood. The males are peaceful creatures and consume nectar and pollen. They say the eyes are the windows to the soul (Figure 75). You will not stare into more beautiful eyes than those of the Tabanidae. The larvae (Figure 20) of most species are aquatic predators. The presence of the strong flying adults means you are within a few miles of water.



Figure 75: Eyes of a Tabanid.

One thing to consider about most of the biting flies is, as larvae, they live in water. If there are numerous flies biting, that is truly a good thing. It means the water quality in the area is clean and able to support life, which in turn means the ecosystem is in decent shape.

- *Asilidae* - The Asilidae, or robber flies, are a fascinating and fun group of flies to study. Asilids are predators and take a wide variety of insects. Some Asilids mimic bumblebees (Figure 76), but the true identity is given away by a characteristic head shape and the presence of distinctive mouthparts that look like a goatee. (Figure 77). Asilids can be found in flight taking dangerous prey much larger than themselves. Three examples are bumblebees, other Asilids, and dragonflies. They pierce the exoskeleton



Figure 76: Asilid flies mating.

of their prey with their “goatee,” inject digestive enzymes to paralyze their prey, and then suck out the contents (remember adult Diptera have liquid diets). Documentation of dragonfly occurrence has been facilitated by utilizing the empty exoskeletons that remain after Asilid predation. County moth records have been established with photos of the moth in the clutches of an Asilid. A tiger beetle, or dragonfly, chew up their prey.



Figure 77: Goatee of Asilids.

Therefore, it is difficult to know what they are eating, but the gentle habits of the Asilidae lend themselves nicely to prey item studies. A checklist to Idaho Asilids (Lavigne, Barr, and Stephens, 2001) is available on the web (as of June 14, 2008) at:

[https://zeus.collegeofidaho.edu/campus/community/museum/IEG/Downloads/IDAHO\\_A\\_SILID\\_CHECKLIST.PDF](https://zeus.collegeofidaho.edu/campus/community/museum/IEG/Downloads/IDAHO_A_SILID_CHECKLIST.PDF)

## Hymenoptera

The order Hymenoptera is known by having four membranous wings with relatively little venation. The hindwings are smaller than the front wings and often hooked to the front pair via the hamuli (Attachment 2 – Insect wings). The first abdominal segment is narrowed to a waist in many forms. This holometabolous order contains some of our most beneficial and damaging of insects: bees, wasps, sawflies, and ants. This order also contains most of our social insects.

- Formicidae - Ants are important: predators, scavengers, recyclers, seed harvesters, soil builders, and more. Everyone has seen an ant, as both are abundant and ubiquitous. Few people see how important these animals are and show them the respect they deserve. There are as many ant species worldwide as there are bird species – but there are many more pounds of ants than birds on our fair planet! Ants are challenging to identify because they exist in many forms or castes: one or more kinds of workers, soldiers, queens, and males. Superficially, each caste can be more like members of the same caste of other species than it is like members of its own species. Ants live in social units where, nominally, all the ants are related. These social units can have animals that live among the ants – social parasites. Some ants do the unthinkable. They enslave other ants. Some ants “kidnap” ants of a different species and have them do the day-to-day chores!

Numerous species of insects are tended by ants (Figure 78), where the ants protect the animal in question. This animal pays tribute to the ants, usually a sweet, sticky substance. Conservation of many of the Lycaenid butterflies probably requires conservation of the ants which protect the larvae.



Figure 78: Ant tending a Western Pygmy-Blue larva.

Figure 79 shows Thatch Ants of the genus *Formica*. Thatch ants build mounds of thatch, which may be three feet tall and can be a conspicuous feature of the Southern Idaho landscape. The mounds serve several functions - thermoregulation is one.



Figure 79: Thatch Ants

- *Bees (many families)* - Honeybees are well known and well liked. Because we know that a honeybee sting is fatal to the bee, the fact that they can sting only adds to their allure. Colony Collapse Disorder (CCD) has been big news lately as honeybees do not return to the hive after they leave. The commercial honeybee, *Apis mellifera*, is an introduced species.

Honeybees are a big business and honeybees are trucked all over the area. We work honeybees hard. We move their hives to pollinate different crops, expose them to mites and diseases as they mingle with other hives from other places. We treat hives with pesticides as a prophylaxis



Figure 80: Horned Lizard, a voracious ant predator.

against disease. The cause of CCD is not currently known but may have something to do with the stressful life we ask these animals to live. Some orchards are responding to CCD, with good success, by managing field margins and fallow lands to provide native bees as pollinators.

CCD is interesting, but there is so much more of interest in the behaviors exhibited by these animals. The Schwänzeltanz, or waggle-dance, is wonderful. The story of how Karl von Frisch discovered this amazing set of communication behaviors is well worth reading. The amount of information communicated is unbelievable too. Scout bees will leave in search of nectar and a bee will return with directions to the source of nectar. She communicates the directions through dance! She will tell worker bees in which direction the nectar is and how far the location is from the hive. Honeybees are well researched. There is still much we do not know. In addition to hive dynamics, pollination ecology is another area that bee students will find worth studying.



Figure 81: Bumble bee nectaring.

The Honey Bee has perennial hives with thousands of workers. Our native bees form primarily annual colonies, if they form colonies at all. Bumble Bee (Figure 81) colonies are much smaller, subterranean dwellings. The Alfalfa Leafcutter Bee is an important pollinator in Idaho agriculture. A visit to [www.xerces.org](http://www.xerces.org) will get you started learning to appreciate native bees.

- *Wasps (many families)* - The term wasp includes several families of Hymenoptera, and numerous lifestyles. Wasps are extremely beneficial insects. Most homeowners will not tolerate them around the home. I have found my garden does much better when yellow jackets (Figure 82) are nesting nearby because they kept pests from damaging the vegetables. In late summer, after the queen is dead and there are no larvae to feed, yellow jackets turn into “sugar punks.” Unfortunately, the new diet also includes your soda. Drinking yellow jackets is an unpleasant experience. My daughter said that Winnie-the-pooh is much more humorous when he has a mouth full of bees than I was when I had the unfortunate experience of finding yellow jackets in my soda! The saddest part of the summer festival of wasps is that only mated queens survive the winter. Idaho is richly populated with wasps: Velvet Ants (they may be called ants, but they are

wingless wasps), Spider Wasps, Braconid Wasps, Thread-waisted Wasps, Digger Wasps, Gall Wasps, Ichneumonid Wasps, and others. All are fascinating and worth discovering.

It is our hope that this document has inspired you to watch for insects as you go about your naturalist activities and has sparked your curiosity about these fascinating animals. As has already been stated, insects are hyper-diverse and exploit just about every possible resource and niche. A naturalist can contribute important, new information to the scientific literature because so much is still unknown about these animals. It seems that field observations always reinforce the adage that:

“There are no rules in the Animal kingdom.” At first, it may seem insane to spend time chasing creatures that weigh less than a piece of paper, fit easily upon a quarter, and can have extremely short life spans. Once you realize the importance of these creatures, you will realize that it is insane not to pay attention to insects. The orders on the following pages are appended to assist you a quick identification characteristics of Insects.



Figure 82: Wasp

INSECT ORDER	COMMON NAME	MOUTH PARTS	WING TYPE	METAMORPHOSIS TYPE	LARVAL TYPE	PUPAL TYPE	KEY CHARACTERISTIC OF ADULT
Collembola	Spring tails	Chewing	Absent	Simple (A)	n/a	n/a	Furcula
Thysanura	Silver fish/ bristle tails	Chewing	Absent	Simple (A)	n/a	n/a	No wings, 3 cerci
Ephemeroptera	Mayflies	Chewing/ vestigial*	Membranous	Simple (H)	n/a	n/a	Large membranous front wings and small hind wings held sail-like over the abdomen
Odonata	Dragonflies/ Damselflies	Chewing	Membranous	Simple (H)	n/a	n/a	Large eyes occupying most of head, setaceous antennae
Orthoptera	Grasshoppers/ Crickets/ Katydid	Chewing	Tegmina	Simple (P)	n/a	n/a	Hind jumping leg
Phasmatodea	Walking sticks	Chewing	Tegmina	Simple (P)	n/a	n/a	Resembles a stick with legs
Dermaptera	Earwigs	Chewing	Elytra	Simple (P)	n/a	n/a	Reduced elytra and forceps-like cerci
Plecoptera	Stoneflies	Chewing	Membranous	Simple (H)	n/a	n/a	Membranous wings held flat over abdomen when at rest, long antennae, two cerci

INSECT ORDER	COMMON NAME	MOUTH PARTS	WING TYPE	METAMORPHOSIS TYPE	LARVAL TYPE	PUPAL TYPE	KEY CHARACTERISTIC OF ADULT
Isoptera	Termites	Chewing	Mostly absent, altates - membranous	Simple (P)	n/a	n/a	Mostly light-colored, ant-like but moniliform antenna not geniculate
Mantodea	Preying mantids	Chewing	Tegmina	Simple (P)	n/a	n/a	Triangular-shaped head, long antenna, tegmina, raptorial legs
Blattodea	Roaches	Chewing	Tegmina	Simple (P)	n/a	n/a	Head concealed by pronotum, tegmina
Hemiptera	True bugs/ aphids/ scales/ hoppers	Piercing-sucking	Hemelytra	Simple (P)	n/a	n/a	Sucking mouthparts – very diverse group; wings – hemelytra, or held tent-like over abdomen
Thysanoptera	Thrips	Rasping-sucking	Fringed wing	Intermediate	n/a	n/a	Fringed wings
Psocoptera	Book and Bark lice	Chewing	Membranous	Simple (P)	n/a	n/a	Swollen clypeus (busted upper lip)
Phthiraptera	True lice	Chewing or sucking	Absent	Simple (P)	n/a	n/a	Wingless, flattened body
Coleoptera	Beetles	Chewing	Elytra	Complete	Campodeiform, Vermiform**, Scarabaeiform**, Elateriform**	Exerate	Elytra, NO cerci

INSECT ORDER	COMMON NAME	MOUTH PARTS	WING TYPE	METAMORPHOSIS TYPE	LARVAL TYPE	PUPAL TYPE	KEY CHARACTERISTIC OF ADULT
Neuroptera	Lace wings/ antlions	Chewing	Membranous	Complete	Campodeiform	Exerate	Membranous wings, antennae may be filiform or other, but not setaceous
Hymenoptera	Ants/ wasps/ bees	Chewing-lapping*	Membranous	Complete	Eruciform**, Vermiform	Exerate	Membranous wings with the anterior margining of hind wing with hamuli
Trichoptera	Caddisflies	Chewing-sucking*	Hairy, held roof-like	Complete	Campodeiform	Exerate	Moth-like but hairy wings NOT scaly
Lepidoptera	Butterflies/ moths	Chewing-sucking*	Scaly	Complete	Eruciform, Vermiform**	Obtect	Scaly wings
Siphonaptera	Fleas	Sucking	Absent	Complete	Vermiform	Exerate	Wingless, laterally flattened
Mecoptera	Scorpionflies	Chewing	Membranous	Complete	Eruciform	Exerate	Head extends below eyes and is often elongated to form a 'beak'
Diptera	Flies/ mosquitoes	Sucking/ spongy	Halteres	Complete	Vermiform	Coarctate, Obtect	Halteres

\* mouth parts differ between adult and immature forms

\*\* not the most common larval form of the order

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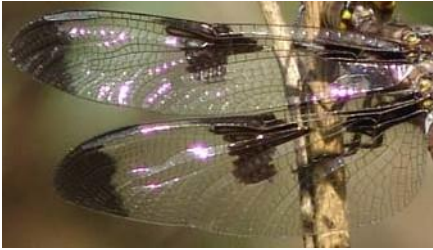
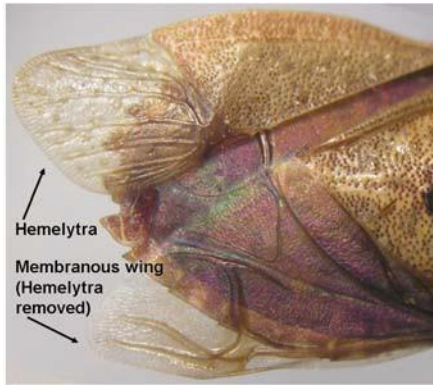
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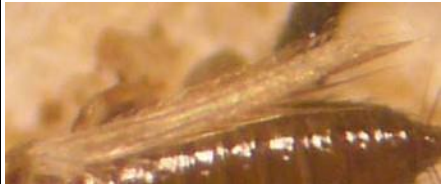

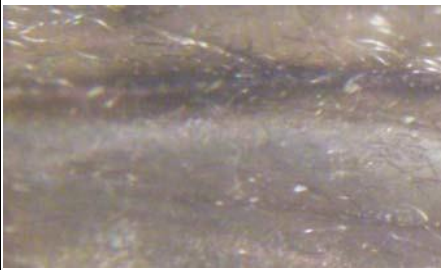

## Descriptions and Terminology of Antennal Types



 <p>Moniliform, or bead-like, antennae are found on termites and others</p>	 <p>Filiform, or thread-like antennae are found on roaches, Carabids and others</p>	 <p>Pectinate, or comb-like, antennae are found on male glow worms and others</p>
 <p>Setaceous, or bristle-like, antennae are found on true bugs and dragonflies</p>	 <p>Serrate, or saw-toothed, antennae are found on click beetles and others</p>	 <p>Aristate antennae are pouch-like with a lateral bristle and are found on some flies</p>
 <p>Lamellate, or plate-like, antennae are found on scarabs</p>	 <p>Geniculate, or elbowed, antennae are found on ants, bees, and weevils</p>	 <p>Plumose antennae are feathery and found on male moths and male mosquitoes</p>
 <p>Capitate, or clubbed, abruptly make a ball at the tip of the antennae – found on butterflies.</p>	 <p>Clavate antennae gradually forms a ball at the tip of the antennae – found on the carrion beetles and others</p>	

## Attachment 2

### Descriptions of Types and Characteristics of Different Insect Wings

	TYPE / CHARACTERISTIC	DESCRIPTION	INSECTS THAT HAVE THIS TYPE
	Tegmina	Forewing is leathery or like parchment in texture	Roaches, preying mantids, and grasshoppers  Orthoptera, Mantodea, Blattodea
	Membranous	Clear wings with many veins, with or without color or patterns	Dragonflies, mayflies, termites and lacewings  Odonata, Ephemeroptera, Neuroptera, and Isoptera (when present)
	Hemelytra	Front wing that is leathery at the base and membranous near the tip, hemelytra covers a membranous wing	True Bugs  Hemiptera (Heteroptera)

	TYPE / CHARACTERISTIC	DESCRIPTION	INSECTS THAT HAVE THIS TYPE
		Wings held roof- like over abdomen	Leaf Hoppers  Hemiptera (Auchenorrhyncha and Sternorrhyncha – formerly Homoptera)
	Fringe-wing	Wings are feather- like (rachis-like structure with fringe or hairs coming off the rachis)	Thrips  Thysanaptera
	Scaly	Front and hind wings covered in scales	Butterflies and moths  Lepidoptera
	Hairy	Hairy wings, not scaly	Caddisflies  Trichoptera
	Elytra	Forewings hard/ sclerotized protect membranous hind wings; forewings meet in the middle covering the abdomen and form a straight line	Beetles and earwigs  Coleoptera and Dermaptera

	TYPE / CHARACTERISTIC	DESCRIPTION	INSECTS THAT HAVE THIS TYPE
	Hamuli	Tiny hooks on the anterior margin of hind wing	Bees and wasps  Hymenoptera
	Halteres	Forewing is membranous, the hind wing is reduced to a knob- like structure	Flies  Diptera

## Attachment 3

### Numbers of Insects\*





ORDER	NORTH AMERICA	WORLD ESTIMATES	FAMILIES IN AMERICAN NORTH OF MEXICO
Protura	73	500	3
Collembola	812	>6,000	12
Diplura	125	800	4
Microcoryphia	24	350	2
Thysanura	20	370	3
Ephemeroptera	599	2,000	21
Odonata	435	5,000	11
Orthoptera	1,210	>20,000	16
Phasmatodea	33	>2,500	4
Gryllobattodea	10	25	1
Mantophasmatodea	-	3	-
Dermaptera	23	1,800	6
Plecoptera	622	2,000	9
Embiidina	11	<200	3
Zoraptera	2	30	1
Isoptera	44	>2,300	4
Mantodea	30	1,800	2
Blattodea	67	<4,000	5
Hemiptera	11,298	3,5000	90
Thysanoptera	695	4,500	7
Psocoptera	264	>3,000	28
Phthiraptera	941	>3,000	18
Coleoptera	24,085	>300,000	128
Neuroptera	400	5,500	15





ORDER	NORTH AMERICA	WORLD ESTIMATES	FAMILIES IN AMERICAN NORTH OF MEXICO
Hymenoptera	20,375	115,000	74
Trichoptera	1,415	>7,000	26
Lepidoptera	11673	150,000	84
Siphonaptera	314	2,380	8
Mecoptera	83	500	5
Strepsiptera	91	550	5
Diptera	19,782	>150,000	103
<b>Total</b>	<b>95,553</b>	<b>826,108</b>	<b>698</b>



**\*An estimation of the number of insects in each order in North America and the world. Adapted from Borror and DeLong's; *Introduction to the Study of Insects*.**

## Attachment 4

### Commonly Encountered Lepidoptera in Idaho

	FAMILY/COMMON NAME	BRIEF DESCRIPTION
	Hesperiidae/ Skippers	33% of all butterflies in North America; “teddy bear-like butterflies;” small butterflies; cute round, furry faces with big eyes; strong fliers; wing color and patterns variable
	Papilionidae/ Swallowtails	Largest and most showy butterflies, hind wing typically has a “tail”
	Pieridae/Whites & Sulphurs	Most are medium sized; most are either white or yellow; many have black markings; not all white or yellow butterflies are Pieridae
	Lycaenidae/ Blues, Coppers, Hairstreaks, & Metalmarks	Typically small, delicate butterflies; underside of wing is different color than upper wing surface; reddish upper wing surface bluish or orange; some have hair-like “tails” on hind wings

	FAMILY/COMMON NAME	BRIEF DESCRIPTION
	Nymphalidae/ Brushfoots & Monarch	Front legs reduced (may appear to have only 4 legs) and bristly, hence “brushfoots;” wing patterns and colors variable; Monarchs and Painted ladies
	Geometridae/ Geometer Moths	Large family; many adults rest with their wings spread; caterpillars are called inchworms.
	Saturniidae/ Silkmoths	Largest Idaho moths, although not all are large; furry bodies, small heads, vestigial moth parts, adults do not feed and are short lived
	Sphingidae/Sphinx or Hawk Moths	Fast powerful fliers; larvae are have a “horn” on the last abdominal segment (hornworms); some species are mistaken as bees or humming birds because they nectar at flowers during the day

	FAMILY/COMMON NAME	BRIEF DESCRIPTION
	Noctuidae/Owlet moths	Largest family of Lepidoptera (25% of all Lepidoptera); variable; they range from small to large; most are non-descript patterned with grey and brown; some are brightly colored; many “worms” are agricultural pests
	Arctiidae/Tiger moths	Most are brightly colored and heavily marked; larvae are hairy or spiny – “woolyworms”